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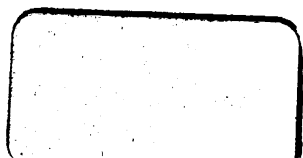
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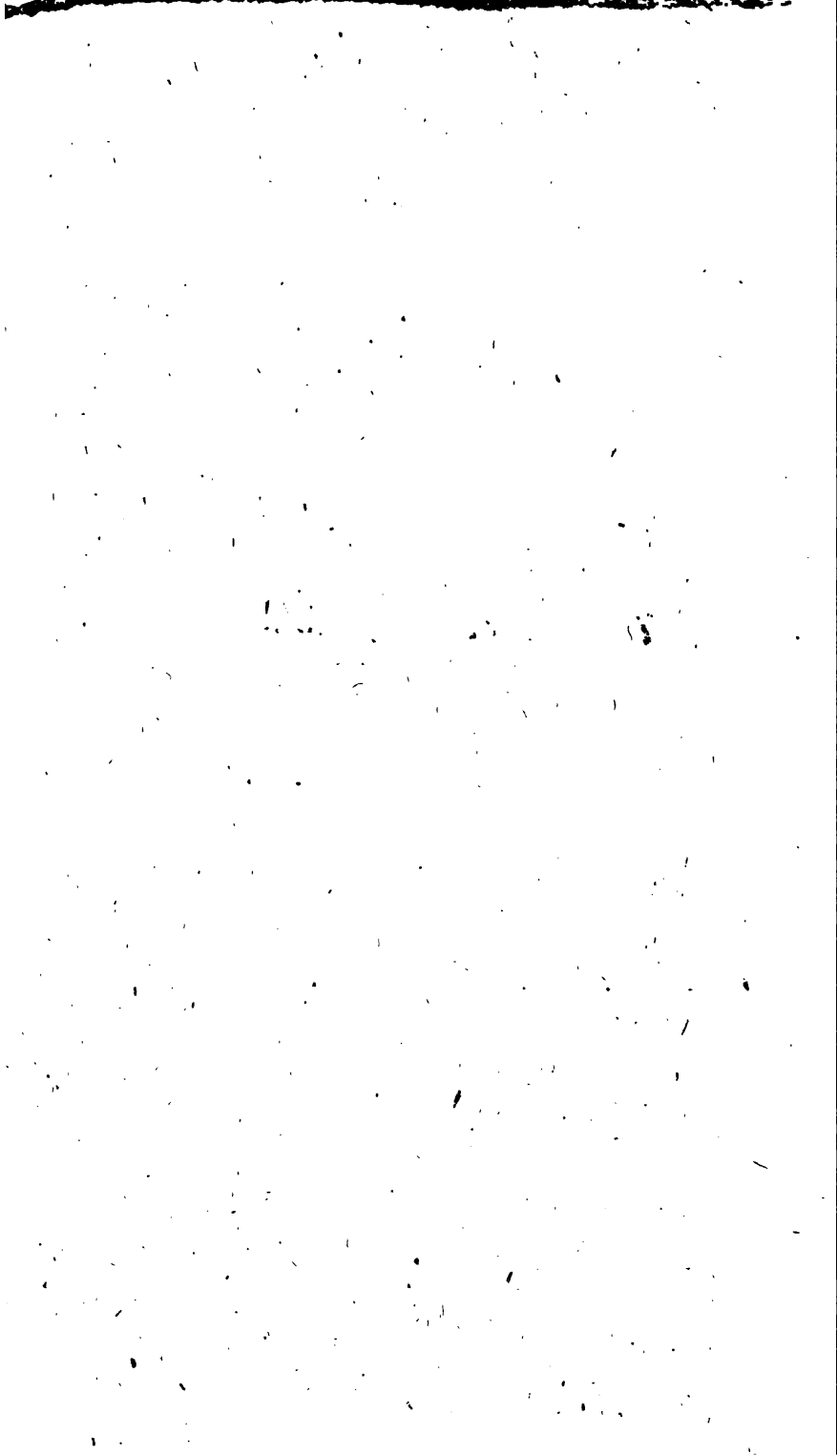






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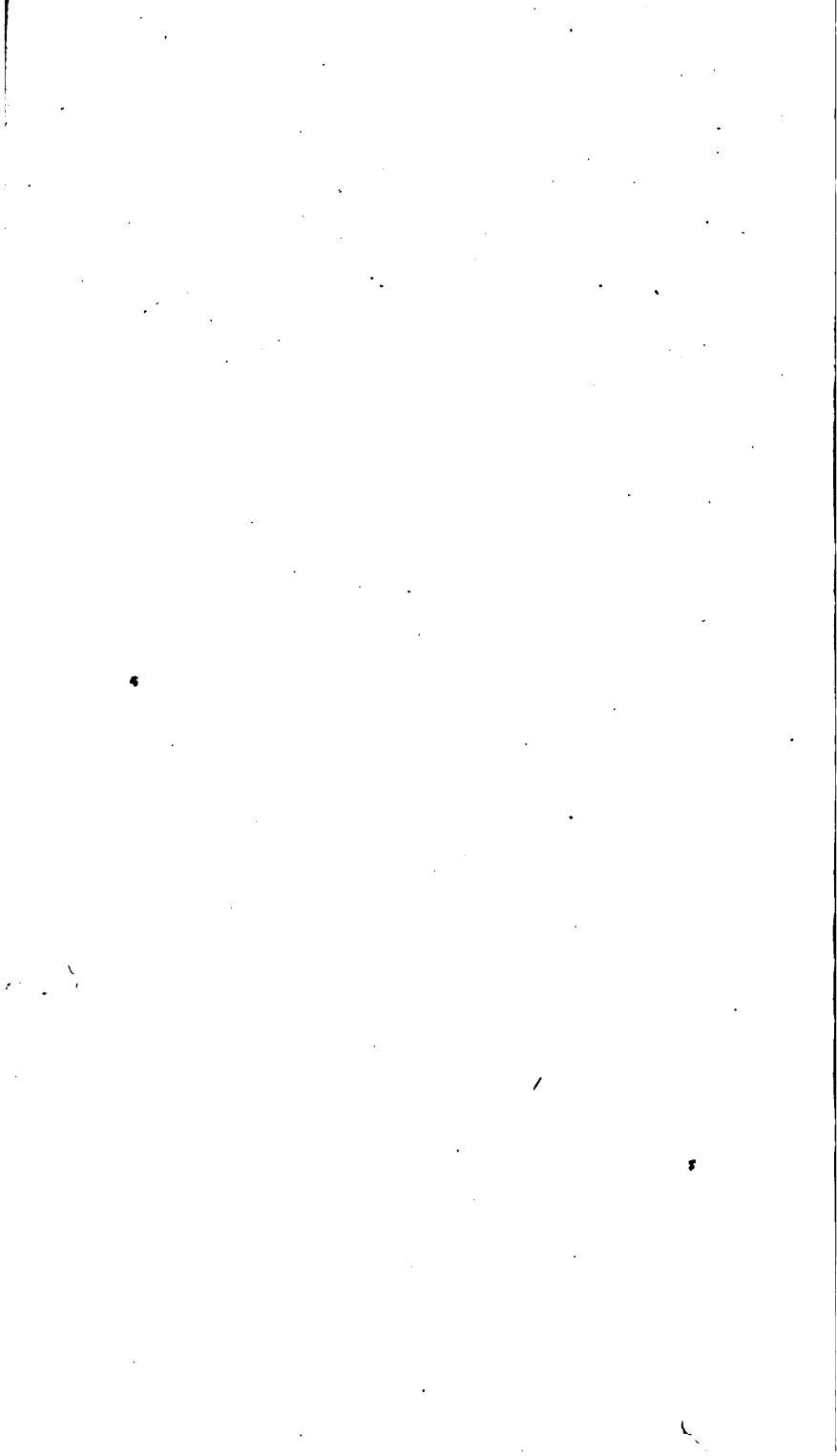




**V O Y A G E**

**T O W A R D S**

**THE NORTH POLE.**



At  
1774

Not in A  
9-29-09  
9/2

A

V O Y A G E  
T O W A R D S  
THE NORTH POLE:

UNDERTAKEN  
BY HIS MAJESTY'S COMMAND,  
1773.

BY CONSTANTINE JOHN PHIPPS.

D U B L I N :  
Printed for Messrs. SLEATER, WILLIAMS, WILSON,  
HUSBAND, WALKER, and JENKIN.

MDCCLXXV.  
1775

477741

T O  
THE KING.

S I R E,

AS a Sea Officer addressing Your MAJESTY on a professional subject, I might justly be accused of singular ingratitude, did I not avail myself of this opportunity of reminding the World, that the Voyage  
to

to explore how far Navigation was practicable towards the North Pole was undertaken at a Period peculiarly distinguished by Your MAJESTY's gracious Attention to Your Navy.

In a Time of profound Peace Your MAJESTY, by a liberal Addition to the Half Pay of the Captains, relieved the Necessities of many, and gratified the Ambition of all, at once demonstrating Your MAJESTY's Regard to their Welfare, and the Remembrance of their Services.

The Armament which followed in a few Months, and Your MAJESTY's Review of that Armament, which, by the Dispatch of its Equipment, had prevented a War, afforded to Your Navy the most flattering  
and

and distinguished Mark of Royal Favour, and to Your MAJESTY an additional Proof of that Alacrity for Your Service, which had so recently received both its Reward and Encouragement from Your MAJESTY's Protection.

Permit me, SIRE, to add, that Your MAJESTY's gracious Approbation of my Endeavours, and the Permission I have been honoured with, of inscribing the following Account of them to Your MAJESTY, are strong Proofs of that Indulgence with which Your MAJESTY receives every Attempt to promote Your Service. — An Indulgence, which, at the same Time that it cannot fail of animating the Zeal of others more worthy of Your  
MAJESTY's



[ viii ]

MAJESTY's Notice, has added to the most  
devoted Attachment, the warmest Grati-  
tude of,

S I R E,

Your MAJESTY's most dutiful

Subject and Servant,

CONSTANTINE JOHN PHIPPS.

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## INTRODUCTION.

**T**HE idea of a passage to the East Indies by the North Pole was suggested as early as the year 1527, by Robert Thorne, merchant, of Bristol, as appears from two papers preserved by Hackluit; the one addressed to king Henry VIII; the other to Dr. Ley, the king's ambassador to Charles V. In that addressed to the king he says, "I know it to be my bounden duty to manifest this secret to your Grace, which hitherto, I suppose, has been hid." This secret appears to be the honour and advantage which would be derived from the discovery of a passage by the North Pole. He represents in the strongest terms the glory which the kings of Spain and Portugal had obtained by their discoveries East and West, and exhorts the king to emulate their fame by undertaking discoveries towards the North. He states in a very masterly style the reputation that must attend the attempt, and the great benefits, should it be crowned with success, likely to accrue

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to the subjects of this country, from their advantageous situation; which, he observes, seems to make the exploring this, the only hitherto undiscovered part, the King's peculiar duty.

To remove any objection to the undertaking which might be drawn from the supposed danger, he insists upon "the great advantages of constant day-light in seas, that, men say, without great danger, difficulty, and peril, yea, rather, it is impossible to pass; for they being past this little way which they named so dangerous (which may be two or three leagues before they come to the Pole, and as much more after they pass the Pole), it is clear from thenceforth the seas and lands are as temperate as in these parts."

In the paper addressed to Dr. Ley he enters more minutely into the advantages and practicability of the undertaking. Amongst many other arguments to prove the value of the discovery, he urges, that by sailing northward and passing the Pole, the navigation from England to the Spice Islands would be shorter, by more than two thousand leagues, than either from Spain by the Straits of Magellan, or Portugal by the Cape of Good Hope; and to shew the likelihood of success in the enterprize he says, it is as probable that the cosmographers should be mistaken in the opinion they entertain of the polar regions being impassable from extreme cold,

## INTRODUCTION. 3

cold, as, it has been found, they were, in supposing the countries under the Line to be uninhabitable from excessive heat. With all the spirit of a man convinced of the glory to be gained, and the probability of success in the undertaking, he adds,—  
 “ God knoweth, that though by it I should have  
 “ no great interest, yet I have had, and still have,  
 “ no little mind of this business: so that if I had  
 “ faculty to my will, it should be the first thing  
 “ that I would understand, even to attempt, *if our*  
 “ *seas Northward be navigable to the Pole or no.*”  
 Notwithstanding the many good arguments, with which he supported his proposition, and the offer of his own services, it does not appear that he prevailed so far as to procure an attempt to be made.

Borne, in his *Regiment of the Sea*, written about the year 1577, mentions this as one of the five ways to Cathay, and dwells chiefly on the mildness of climate which he imagines must be found near the Pole, from the constant presence of the sun during the summer. These arguments, however, were soon after controverted by Blundeville, in his *Treatise on Universal Maps*.

In 1578, George Best, a gentleman who had been with Sir Martin Frobisher in all his voyages for the discovery of the North West passage, wrote a very ingenious discourse, to prove all parts of the world habitable.

No voyage, however, appears to have been undertaken to explore the circumpolar seas, till the year 1607, when "Henry Hudson was set forth, at the charge of certain worshipful merchants of London, to discover a passage by the "North Pole to Japan and China." He sailed from Gravesend on the first of May, in a ship called the Hopewell, having with him ten men and a boy. I have taken great pains to find his original journal, as well as those of some others of the adventurers who followed him; but without success: the only account I have seen is an imperfect abridgement in Purchas, by which it is not possible to lay down his track; from which, however, I have drawn the following particulars:—He fell in with the land to the Westward in latitude  $73^{\circ}$ , on the twenty-first of June, which he named Hold-with-Hope. The twenty-seventh, he fell in with Spitzbergen, and met with much ice; he got to eighty degrees twenty-three minutes, which was the Northernmost latitude he observed in. Giving an account of the conclusion of his discoveries, he says, "On the sixteenth of August I saw land, by reason of the clearness of the weather, *stretching far into eighty-two degrees*, and, by the bowing and shewing of the sky, much farther; which when I first saw, I hoped to have had a free sea between the land and the ice, and meant to have compassed this land by the North; but now find-

"ing

## INTRODUCTION. 5

“ing it was impossible, by means of the abundance  
 “of ice compassing us about by the North, and  
 “joining to the land; and seeing God did bless us  
 “with a wind, we returned, bearing up the helm.”  
 He afterwards adds: “And this I can assure at  
 “this present, that between seventy-eight degrees  
 “and an half, and eighty-two degrees, by this  
 “way there is no passage.”—In consequence of  
 this opinion, he was the next year employed on  
 the North East discovery.

In March 1609, old style, “A voyage was set  
 “forth by the right worshipful Sir Thomas Smith,  
 “and the rest of the Muscovy Company, to Cherry  
 “Island, and for a further discovery to be made  
 “towards the North Pole, for the likelihood of a  
 “trade or a passage that way, in the ship called the  
 “Amity, of burthen seventy tuns, in which Jonas  
 “Poole was master, having fourteen men and one  
 “boy.”—He weighed from Blackwall, March the  
 first, old style; and after great severity of weather,  
 and much difficulty from the ice, he made the  
 South part of Spitsbergen on the 16th of May. He  
 sailed along and sounded the coast, giving names to  
 several places, and making many very accurate ob-  
 servations. On the 26th, being near Fair Foreland,  
 he sent his mate on shore;—and speaking of the ac-  
 count he gave at his return, says, “Moreover, I  
 “was certified that all the ponds and lakes were  
 “unfrozen, they being fresh water; which putteth

## 6 INTRODUCTION.

“ me in hope of a mild summer here, after so sharp  
 “ a beginning as I have had ; and my opinion is  
 “ such, and I assure myself it is so, that a passage  
 “ may be as soon attained this way by the Pole, as  
 “ any unknown way whatsoever, by reason the sun  
 “ doth give a great heat in this climate, and the  
 “ ice (I mean that freezeth here) is nothing so huge  
 “ as I have seen in seventy-three degrees.”

These hopes, however, he was soon obliged to relinquish for that year, having twice attempted in vain to get beyond  $79^{\circ} 50'$ . On the 21st of June, he stood to the Southward, to get a loading of fish, and arrived in London the last of August. He was employed the following year (1611) in a small bark called the Elizabeth, of 50 tuns. The instructions for this voyage, which may be found at length in Purchas, are excellently drawn up : They direct him, after having attended the fishery for some time, to attempt discoveries to the North Pole as long as the season will permit ; with a discretionary clause, to act in unforeseen cases as shall appear to him most for the advancement of the discovery, and interest of his employers. This however proved an unfortunate voyage : for having staid in Cross Road till the 16th of June, on account of the bad weather, and great quantity of ice, he sailed from thence on that day, and steered W b N fourteen leagues, where he found a bank of ice : he returned to Cross-Road ; from whence  
 when

## INTRODUCTION. 7

when he sailed, he found the ice to lie close to the land about the latitude of  $80^{\circ}$ , and that it was impossible to pass that way; and the strong tides making it dangerous to deal with the ice, he determined to stand along it to the Southward, to try if he could find the sea more open that way, and so get to the Westward, and proceed on his voyage. He found the ice to lie nearest S W and S W b S and ran along it about an hundred and twenty leagues. He had no ground near the ice at 160, 180, or 200 fathoms: perceiving the ice still to trend to the southward, he determined to return to Spitzbergen for the fishery, where he lost his ship.

In the year 1614, another voyage was undertaken, in which Baffin and Fotherby were employed. With much difficulty, and after repeated attempts in vain with the ship, they got with their boats to the firm ice, which joined to Red-Beach; they walked over the ice to that place, in hopes of finding whale-fins, &c. in which they were disappointed. Fotherby adds, in his account: "Thus, "as we could not find what we desired to see, so "did we behold that which we wished had not "been there to be seen; which was great abundance of ice, that lay close to the shore, and "also off at sea as far as we could discern." On the eleventh of August they sailed from Fair-Haven, to try if the ice would let them pass to the Northward, or Northeastward; they steered from



### 3 INTRODUCTION.

Cape Barren, or Vogel Sang, NE b E eight leagues, where they met with the ice, which lay Eb S and W b N. The fifteenth of August they saw ice frozen in the sea of above the thickness of an half-crown.

Fotherby was again fitted out the next year in a pinnace of twenty tons, called the Richard, with ten men. In this voyage he was prevented by the ice from getting farther than in his last. He refers to a chart, in which he had traced the ship's course on every traverse, to shew how far the state of that sea was discovered between eighty and seventy-one degrees of latitude, and for twenty-six degrees of longitude from Hackluit's headland. He concludes the account of his voyage in the following manner :

“ Now, if any demand my opinion concerning  
“ hope of a passage to be found in those seas, I  
“ answer; that it is true, that I both hoped and  
“ much desired to have passed further than I did,  
“ but was hindered with ice; wherein although I  
“ have not attained my desire, yet forasmuch as it  
“ appears not yet to the contrary, but that there is  
“ a spacious sea betwixt Groinland and king James  
“ his new land [Spitzbergen] although much pe-  
“ tered with ice; I will not seem to diswade this  
“ worshipful company from the yearly adventuring  
“ of

## INTRODUCTION. 9

“ of 150 or 200 pounds at the most, till some further discovery be made of the said seas and lands adjacent.” It appears that the Russia company, either satisfied with his endeavours and despairing of further success, or tired of the expence of the undertaking, never employed any more ships on this discovery.

All these voyages having been fitted out by private adventurers, for the double purpose of discovery and present advantage; it was natural to suppose, that the attention of the navigators had been diverted from pursuing the more remote and less profitable object of the two, with all the attention that could have been wished. I am happy, however, in an opportunity of doing justice to the memory of these men; which, without having traced their steps, and experienced their difficulties, it would have been impossible to have done. They appear to have encountered dangers, which at that period must have been particularly alarming from their novelty, with the greatest fortitude and perseverance; as well as to have shewn a degree of diligence and skill, not only in the ordinary and practical, but more scientific parts of their profession, which might have done honour to modern seamen, with all their advantages of later improvements. This, when compared with the accounts given of the state of navigation, even within these  
forty

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forty years, by the most eminent foreign authors, affords the most flattering and satisfactory proof of the very early existence of that decided superiority in naval affairs, which has carried the power of this country to the height it has now attained.

This great point of geography, perhaps the most important in its consequences to a commercial nation and maritime power, but the only one which had never yet been the object of royal attention, was suffered to remain without further investigation, from the year 1615 till 1773, when the Earl of Sandwich, in consequence of an application which had been made to him by the Royal Society, laid before his Majesty, about the beginning of February, a proposal for an expedition to try how far navigation was practicable towards the North Pole; which his Majesty was pleased to direct should be immediately undertaken, with every encouragement that could countenance such an enterprize, and every assistance that could contribute to its success.

As soon as I heard of the design, I offered myself, and had the honour of being entrusted with the conduct of this undertaking. The nature of the voyage requiring particular care in the choice and equipment of the ships, the Racehorse and Carcass bombs were fixed upon as the strongest, and

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and therefore properest for the purpose. The probability that such an expedition could not be carried on without meeting with much ice, made some additional strengthening necessary : they were therefore immediately taken into dock, and fitted in the most compleat manner for the service. The complement for the Racehorse was fixed at ninety men, and the ordinary establishment departed from, by appointing an additional number of officers, and entering effective men instead of the usual number of boys.

I was allowed to recommend the officers; and was very happy to find, during the course of the voyage, by the great assistance I received on many occasions from their abilities and experience, that I had not been mistaken in the characters of those upon whom so much depended in the performance of this service. Two masters of Greenlandmen were employed as pilots for each ship. The Racehorse was also furnished with the new chain-pumps made by Mr. Cole according to Captain Bentinck's improvements, which were found to answer perfectly well. We also made use of Dr. Irving's apparatus for distilling fresh water from the sea, with the greatest success. Some small but useful alterations were made in the species of provisions usually supplied in the navy; an additional quantity of spirits was allowed for each ship, to be issued at the discretion of the commanders, when extraordinary fatigue

fatigue or severity of weather might make it expedient. A quantity of wine was also allotted for the use of the sick. Additional clothing, adapted to that rigor of climate, which from the relations of former navigators we were taught to expect, was ordered to be put on board, to be given to the seamen when we arrived in the high latitudes. It was foreseen that one or both of the ships might be sacrificed in the prosecution of this undertaking; the boats for each ship were therefore calculated, in number and size, to be fit, on any emergency, to transport the whole crew. In short, every thing which could tend to promote the success of the undertaking, or contribute to the security, health, and convenience of the ships' companies, was granted.

The Board of Longitude agreed with Mr. Israel Lyons to embark in this voyage, to make astronomical observations. His reputation for mathematical knowledge was too well established to receive any addition from the few opportunities which a voyage in such unfavourable climates could afford. The same Board supplied him with such instruments as they imagined might be useful for making observations and experiments. The Royal Society favoured me with such information as they judged might serve to direct my enquiries, whenever the circumstances of the voyage should afford me leisure and opportunity for making observations.

Besides

Besides these learned bodies, I was obliged to many individuals for hints; amongst whom it is with pleasure I mention Monsieur D'Alembert, who communicated to me a short paper, which, from the conciseness and elegance with which it was drawn up, as well as from the number of interesting objects that it recommended to my attention, would have done honour to any person whose reputation was not already established upon so solid a foundation as that learned philosopher's. To Mr. Banks I was indebted for very full instructions in the branch of natural history, as I have since been for his assistance in drawing up the account of the productions of that country; which I acknowledge with particular satisfaction, as instances of a very long friendship which I am happy in an opportunity of mentioning.

As a voyage of this kind would probably afford many opportunities of making experiments and observations in matters relative to navigation, I took care to provide myself with all the best instruments hitherto in use, as well as others which had been imperfectly, or never, tried.

The length of the Second Pendulum in so high a latitude as I was likely to reach, appearing to me an experiment too interesting to be neglected, I desired Mr. Cumming to make me such an instrument as he thought would best answer the purpose.

That

That modesty and candour which always attend real merit, induced him to lend me the identical pendulum with which Mr. Graham had made his experiments, rather than furnish me with one of his own construction; but the judgment as well as skill with which the apparatus joined to it was contrived and executed, notwithstanding the shortness of the time, will, I am sure, do him credit.

The Board of Longitude sent two watch machines for keeping the longitude by difference of time; one constructed by Mr. Kendal, on Mr. Harrison's principles; the other by Mr. Arnold. I had also a pocket watch constructed by Mr. Arnold, by which I kept the longitude to a degree of exactitude much beyond what I could have expected; the watch having varied from its rate of going only 2' 40" in 128 days.

In the Journal which follows, I mean to confine myself to the occurrences of the voyage as they succeeded in order of time; which, for the convenience of the generality of readers, I have reduced from the nautical to the civil computation: to this I shall add, by way of Appendix, an account of all the experiments and observations under their respective heads, that those who interest themselves in any particular branch, may find whatever they want, unmixed with foreign matters; while those who may wish only to trace the whole

whole progress of the voyage, as well as those who may be satisfied with the general results of the experiments, will find the account unincumbered with that detail which I wish to submit to others, who may chuse to examine more minutely, and compare the facts with the conclusions.

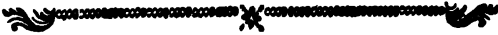
A voyage of a few months to an uninhabited extremity of the world, the great object of which was to ascertain a very interesting point in geography, cannot be supposed to afford much matter for the gratification of mere curiosity. The experiments and observations may possibly from their novelty, and the peculiar circumstances of the climate in which they were made, afford some entertainment to philosophers; and might perhaps have been more numerous and satisfactory, if the pursuit of the great object of the voyage had not rendered them, however interesting in themselves, but a secondary consideration.







# JOURNAL.





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# JOURNAL.

**A**PRIL 19th, 1773, I received my commission for the *Racchose*, with an order to get her fitted with the greatest dispatch for a voyage of discovery towards the North Pole, and to proceed to the *Nore* for further orders.

23d. The ship was hauled out of dock.

May 21st. The ship being manned and rigged, and having got in all the provisions and stores, except the Gunner's, we fell down to *Galleons*.

22d. We received on board the powder, with eight six-pounders, and all the gunner's stores. Lord Sandwich gave us the last mark of the obliging attention he had shewn during the whole progress of the equipment, by coming on board to satisfy himself, before our departure, that the whole had been compleated to the wish of those who were embarked in the expedition. The Easterly

winds prevented our going down the river till the 26th, when I received my instructions for the voyage, dated the 25th; directing me to fall down to the Nore in the Race-horse, and there taking under my command the Carcass, to make the best of my way to the Northward, and proceed up to the North Pole, or as far towards it as possible, and as nearly upon a meridian as the ice or other obstructions might admit; and, during the course of the voyage, to make such observations of every kind as might be useful to navigation, or tend to the promotion of natural knowledge: in case of arriving at the Pole, and even finding free navigation on the opposite meridian, not to proceed any farther; and at all events to secure my return to the Nore before the winter should set in. There was also a clause authorizing me to proceed, in unforeseen cases, according to my own discretion; and another clause directing me to prosecute the voyage on board the Carcass, in case the Racehorse should be lost or disabled.

27th. I anchored at the Nore, and was joined by Captain Lutwidge, in the Carcass, on the 30th: her equipment was to have been in all respects the same as that of the Racehorse, but when fitted, Captain Lutwidge finding her too deep in the water to proceed to sea with safety, obtained leave of the Admiralty to put six more guns on shore, to reduce the complement to eighty men, and return  
a quantity

a quantity of provisions proportionable to that reduction. The officers were recommended by Captain Lutwidge, and did justice to his penetration by their conduct in the course of the voyage. During our stay here, Mr. Lyons landed with the astronomical quadrant at Sheerness fort, and found the latitude to be  $51^{\circ} 31' 30''$ , longitude  $0^{\circ} 30'$  East. The Easterly winds prevented our moving this day and the following.

June 2d. Having the wind to the Westward of North, at five in the morning I made the signal to weigh; but in less than half an hour, the wind shifting to the Eastward and blowing fresh, I furled the topsails. The wind came in the afternoon to N b E; we weighed, but did not get far, the tide of flood making against us.

3d. The wind blowing fresh all day Easterly, we did not move.

4th. The wind coming round to the Westward at six in the morning, I weighed immediately, and sent the boat for Captain Lutwidge, to deliver him his orders. At 10 A. M. longitude by the watch  $56'$  E. At noon the latitude observed was  $51^{\circ} 37' 36''$  N. At eight in the evening we had got as far as Balfey Cliff, between Orford and Harwich. Little wind at night.

5th. Anchored in Hoveley Bay at half past seven in the evening, in five and an half fathom water. Orford Castle NEbN.

|                                      |          |
|--------------------------------------|----------|
| Angle between Aldborough Church and  | } 7° 38' |
| Orford Light House,                  |          |
| Light House and Orford Church, . . . | 18 16    |
| Orford Church and Castle, . . . . .  | 2 20     |
| Castle and Hoveley Church, . . . . . | 100 59   |
| Hoveley and Balfey Church, . . . . . | 35 27    |

6th. At five in the morning, the wind at SSW, weighed, and stood out to sea, finding I might lose two tides by going through Yarmouth Roads. Examined the log line, which was marked forty-nine feet; the glass was found, by comparing it with the time-keeper, to run thirty seconds: at noon latitude observed  $52^{\circ} 16' 54''$ , longitude by the watch  $1^{\circ} 30' 15''$  E.

|  |           |
|--|-----------|
| Angle between Southwold and Walderf-   | } 10° 39' |
| wick, . . . . .  |           |
| Walderfwick and Dunwich, . . . . .   | 20 21     |
| Dunwich and Aldborough, . . . . .  | 46 53     |
| Southwold N W $\frac{1}{2}$ N, supposed distance three leagues. We concluded the latitude of Southwold to be $52^{\circ} 22'$ , and longitude $1^{\circ} 18' 15''$ E. The dip was $73^{\circ} 22'$ . |           |

7th.

7th. The wind was Northerly all day, and blew fresh in the morning. We had stood far out in the night and the day before, to clear the Lemon and Ower.

8th. Little wind most part of the day, with a very heavy swell. Stood in for the land. At half past ten longitude by the watch  $0^{\circ} 41' 15''$  E. At noon the latitude was  $53^{\circ} 38' 37''$ . We saw the high land near the Spurn, in the evening.

9th. About noon Flamborough Head bore NW b N distant about six miles: we were by observation in latitude  $54^{\circ} 4' 54''$ , longitude  $0^{\circ} 27' 15''$  E; which makes Flamborough Head, in latitude  $54^{\circ} 9'$ , longitude  $0^{\circ} 19' 15''$  E. In the afternoon we were off Scarborough. Almost calm in the evening.

10th. Anchored in the morning for the tide in Robin Hood's Bay, with little wind at N W: worked up to Whitby Road next tide, and anchored there at four in the afternoon, in fifteen fathom, with very little wind.

11th. Calm in the morning; compleated our water, live stock and vegetables. At nine in the morning longitude observed by the watch  $1^{\circ} 55' 30''$  W; Whitby Abbey bore  $S \frac{1}{2} W$ . Weighed



with the wind at S E, and steered N E b N to get so far into the mid-channel as to make the wind fair Easterly or Westerly, without being too near either shore, before we were clear of Shetland and the coast of Norway.

12th. The wind at S E, and the ship well advanced, I ordered the allowance of liquor to be altered, serving the ship's company one-fourth of their allowance in beer, and the other three-fourths in brandy; by which means the beer was made to last the whole voyage, and the water considerably saved. One half of this allowance was served immediately after dinner, and the other half in the evening. It was now light enough all night to read upon deck.

13th. The weather still fine, but considerably less wind than the day before, and in the afternoon more Northerly. The longitude at ten in the morning was found by my watch  $0^{\circ} 6' W$ . We took three observations of the moon and sun for the longitude; the extremes differed from one another near two degrees: the mean of the three gave the longitude  $1^{\circ} 37' E$ . At noon the latitude observed was  $59^{\circ} 32' 31''$ . We found a difference of  $36'$  between the latitude by dead reckoning and observation, the ship being so much more Northerly than the reckoning. The distance by this log was  
too

too short by forty-three miles. A log marked forty-five feet, according to the old method, would have agreed with the observation within two miles in the two days' run. The circumstance of steering upon a meridian, which afforded me such frequent opportunities of detecting the errors of the log, induced me to observe with care the comparative accuracy of the different methods of dividing the line, recommended by mathematicians, or practised by seamen. In the afternoon I went on board the *Carcass* to compare the time-keepers by my watch. At six in the evening the longitude by my watch  $0^{\circ} 4' E$ . This evening the sun set at twenty-four minutes past nine, and bore about *NNW* by the compass. The clouds made a beautiful appearance long after to the Northward, from the reflection of the sun below the horizon. It was quite light all night: the *Carcass* made the signal for seeing the land in the evening.

14th. Little wind, or calm, all day; but very clear and fine weather. Made several different observations for the longitude by the sun and moon, and by my watch. The longitude of the ship was found by my watch, at ten in the morning, to be  $1^{\circ} 11' 45'' W$ . The longitude by the lunar observations differed near two degrees from one another. By the mean of them the ship was in longitude  $2^{\circ} 57' 45'' W$ . Some Shetland boats came on board with fish. At noon the latitude by observation

tion was  $60^{\circ} 16' 45''$ . At one in the afternoon the dip was observed to be  $73^{\circ} 30'$ ; and at eight,  $75^{\circ} 18'$ : the evening calm, and very fine; the appearance of the sky to the Northward very beautiful. Variation, by the mean of several observations,  $22^{\circ} 25' W$ .

15th. By an observation at eight in the morning, the longitude of the Dip was by the watch  $0^{\circ} 39' W$ : Dip  $74^{\circ} 52'$ . At half past ten in the morning, the longitude, from several observations of the sun and moon, was  $0^{\circ} 17' W$ ; at noon being in latitude  $60^{\circ} 19' 8''$ , by observation, I took the distance between the two ships by the Megameter; and from that base determined the position of Hangcliff, which had never before been ascertained, though it is a very remarkable point, and frequently made by ships. According to these observations it is in latitude  $60^{\circ} 9'$ , and longitude  $0^{\circ} 56' 30'' W$ . In the Appendix I shall give an account of the manner of taking surveys by this instrument, which I believe never to have been practised before. At one, observed the dip to be  $75^{\circ}$ . A thick fog came on in the afternoon, with a flat calm; we could not see the Carcass, but heard her answer the signals for keeping company. Variation, from the mean of several observations,  $25^{\circ} 1' W$ .

16th.

16th. A very thick fog in the morning; latitude observed at noon  $60^{\circ} 29' 17''$ : the dip was observed at nine in the evening to be  $76^{\circ} 45'$ . In the afternoon, the weather clear, and the wind fair, steered N N E: sent Captain Lutwidge his further orders and places of rendezvous.

17th. Wind fair, and blowing fresh at S S W, continued the course N N E: ordered the people a part of the additional clothing: saw an English sloop, but had no opportunity of sending letters on board, the sea running high. At ten in the morning, longitude by the watch  $0^{\circ} 19' 45''$  W: at noon, the latitude observed was  $62^{\circ} 59' 27''$ . The ship had out-run the reckoning eleven miles. I tried Bouguer's log twice this day, and found it give more than the common log. Variation  $19^{\circ} 22'$  W.

18th. Little wind all day, but fair, from S S W to S E: still steering N N E: latitude observed at noon  $65^{\circ} 18' 17''$ . At three in the afternoon, sounded with 300 fathom of line, but got no ground. Longitude by the watch  $1^{\circ} 0' 30''$  W.

19th. Wind to the N W. Took the meridian observation at midnight for the first time: the sun's lower limb  $0^{\circ} 37' 30''$  above the horizon; from  
which

which the latitude was found  $66^{\circ} 54' 39''$  N: at four in the afternoon, longitude by the watch  $0^{\circ} 58' 45''$  W: at six the variation  $19^{\circ} 11'$  W.

20th. Almost calm all day. The water being perfectly smooth, I took this opportunity of trying to get soundings at much greater depths than I believe had ever been attempted before. I sounded with a very heavy lead the depth of 780 fathom, without getting ground; and by a thermometer invented by lord Charles Cavendish for this purpose, found the temperature of the water at that depth to be  $26^{\circ}$  of Fahrenheit's thermometer; the temperature of the air being  $48^{\circ} \frac{1}{2}$ .

We began this day to make use of Doctor Irving's apparatus for distilling fresh water from the sea: repeated trials gave us the most satisfactory proof of its utility: the water produced from it was perfectly free from salt, and wholesome, being used for boiling the ship's provisions; which convenience would alone be a desirable object in all voyages, independent of the benefit of so useful a resource in case of distress for water. The quantity produced every day varied from accidental circumstances, but was generally from thirty-four to forty gallons, without any great addition of fuel. Twice indeed the quantity produced was only twenty-three gallons on each distillation; this amounts to more than

than a quart for each man, which, though not a plentiful allowance, is much more than what is necessary for subsistence. In cases of real necessity I have no reason to doubt that a much greater quantity might be produced without an inconvenient expence of fuel.

21st. A fresh gale at S E all day ; steered NNE. At four in the morning we spoke with a snow from the seal fishery, bound to Hamburgh, by which we sent some letters. At six in the morning the variation, by the mean of several observations, was  $23^{\circ} 18'$  W. Longitude by the watch at nine was  $0^{\circ} 34' 30''$  W. Latitude observed at noon  $68^{\circ} 5'$ .

22d. Calm most part of the day ; rainy and rather cold in the evening. At noon observed the dip to be  $77^{\circ} 52'$ .

23d. Very foggy all day ; the wind fair ; altered the course and steered NE and ENE, to get more into the mid channel, and to avoid falling in with the Western ice, which, from the increasing coldness of the weather, we concluded to be near. At seven o'clock in the morning, being by our reckoning to the Northward of  $72^{\circ}$ , we saw a piece of drift wood, and a small bird called a Redpoll. Dip observed at nine in the evening to be  $81^{\circ} 30'$ .

17th. 24th. Very foggy all the morning; the wind came round to the Northward. The dip observed at noon was  $80^{\circ} 35'$ . In the afternoon, the air much colder than we had hitherto felt it; the thermometer at  $34^{\circ}$ . A fire made in the cabin for the first time, in latitude  $73^{\circ} 40'$ .

25th. Wind Northerly, with a great swell; some snow, but in general clear. At eight in the morning, the longitude observed by the watch was  $7^{\circ} 15'$  E. Made several observations on the variation, which we found, by those taken at seven in the morning, to be  $17^{\circ} 9'$  W; by others at three in the afternoon, only  $7^{\circ} 47'$  W. I could not account for this very sudden and extraordinary decrease, as there were several different observations taken both in the morning and evening, which agreed perfectly well with each other, without any apparent cause which could produce an error affecting all the observations of either set. At eight in the evening the longitude by the moon was  $12^{\circ} 57' 30''$  E, which differed  $2^{\circ} 35'$  from that by the watch. Little wind at night.

26th. Little wind all day; the weather very fine and moderate. The latitude observed at noon was  $74^{\circ} 25'$ . The thermometer exposed to the sun, which shone very bright, rose from  $41^{\circ}$  to  $61^{\circ}$  in  
twenty

June.] J O U R N A L. 31

twenty minutes. By each of two lunar observations which I took with a sextant of four inches radius, at half past one, the longitude was  $9^{\circ} 57' 30''$  E; which agreed within thirty-seven minutes with an observation made by the watch at half an hour after three, when the longitude was  $8^{\circ} 52' 30''$  E. Dip  $79^{\circ} 22'$ .

27th. At midnight the latitude observed was  $74^{\circ} 26''$ . The wind came to the S W, and continued so all day, with a little rain and snow. The cold did not increase. We steered N b E. At seven in the morning the variation, by a mean of several observations, was found to be  $20^{\circ} 38'$  W. We were in the evening, by all our reckonings, in the latitude of the South part of Spitzbergen, without any appearance of ice or sight of land, and with a fair wind.

28th. Less wind in the morning than the day before, with rain and fleet: continued steering to the Northward. At five in the afternoon picked up a piece of drift wood, which was fir, and not worm-eaten: sounded in 290 fathom; no ground. At six the longitude by the watch was  $7^{\circ} 50'$  E: between ten and eleven at night, saw the land to the Eastward at ten or twelve leagues distance. At midnight, dip  $81^{\circ} 7'$ .

29th.



29th. The wind Northerly; stood close in with the land. The coast appeared to be neither habitable nor accessible; it was formed by high, barren, black rocks, without the least marks of vegetation; in many places bare and pointed, in other parts covered with snow, appearing even above the clouds: the vallies between the high cliffs were filled with snow or ice. This prospect would have suggested the idea of perpetual winter, had not the mildness of the weather, the smooth water, bright sunshine, and constant day-light, given a cheerfulness and novelty to the whole of this striking and romantick scene.

I had an opportunity of making many observations near the Black Point. Latitude observed at noon  $77^{\circ} 59' 11''$ . The difference of latitude, from the last observation on the 27th at midnight to this day at noon, would according to the old method of marking the log have been two hundred and thirteen miles; which agrees exactly with the observation. At three in the afternoon, brought to and sounded 110 fathom; soft muddy ground: hoisted out the boat and tried the stream; found it, both by the common and Bouguer's log (which agreed exactly) to run half a knot North; Black Point bearing E N E. At four the longitude by the watch was  $9^{\circ} 31' E$ : at eight the variation, by the mean of nineteen observations,  $11^{\circ} 53' W$ .

I could

I could not account from any apparent cause for this great change in the variation: the weather was fine, the water smooth, and every precaution we could think of used to make the observations accurate. The dip was  $80^{\circ} 26'$ . Plying to the Northward.

30th. At midnight the latitude by observation was  $78^{\circ} 0' 50''$ . At four in the morning, by Lord Charles Cavendish's thermometer the temperature of the water at the depth of 118 fathoms was  $31^{\circ}$  of Fahrenheit's; that of the air was at the same time  $40^{\circ} \frac{1}{2}$ . At nine in the morning we saw a ship in the N W, standing in for the land. Having little wind this morning, and that Northerly, I stood in for the land, with an intention to have watered the ship, and got out immediately, but was prevented by the calm which followed. At noon the latitude observed was  $78^{\circ} 8'$ ; the dip  $79^{\circ} 30'$ . At two in the afternoon we sounded in 115 fathom; muddy bottom: at the same time we sent down Lord Charles Cavendish's thermometer, by which we found the temperature of the water at that depth to be  $33^{\circ}$ ; that of the water at the surface was at the same time  $40^{\circ}$ ; and in the air  $44^{\circ} \frac{1}{2}$ . Fahrenheit's thermometer plunged in water brought up from the same depth, stood at  $38^{\circ} \frac{1}{2}$ . This evening the master of a Greenland Ship came on board, who told me, that he was just come out of the ice which lay to the

Westward about sixteen leagues off, and that three ships had been lost this year, two English, and one Dutch. The weather fine, and rather warm. At six in the evening the longitude by my watch was  $9^{\circ} 28' 45''$  E.

July 1st. Little wind Northerly, or calm, all day: the weather very fine, and so warm that we sat without a fire, and with one of the ports open in the cabin. At noon the latitude observed was  $78^{\circ} 13' 36''$ ; Black Point bearing S  $78^{\circ}$  E; which makes the latitude of that point nearly the same as that of the ship, and agrees very well with the chart of this coast in Purchas.

2d. Little wind, and calms, all day; the weather very fine. At six in the morning five sail of Greenlandmen in sight. At noon the latitude observed was  $78^{\circ} 22' 41''$ . I took a survey of the coast, as far as we could see: I took also with the megameter the altitudes of several of the mountains: but as there is nothing particularly interesting to navigators in this part of the coast, I shall only mention the height of one mountain, which was fifteen hundred and three yards. This may serve to give some idea of the appearance and scale of the coast. At half past six the longitude by the watch was  $9^{\circ} 8' 30''$  E: Variation  $14^{\circ} 55'$  W.

3. Latitude

3. Latitude at midnight  $78^{\circ} 23' 46''$ : Dip  $80^{\circ} 45'$ . The weather fine, and the wind fair all day. Running along by the coast of Spissbergen all day: several Greenlandmen in sight. Between nine and ten in the evening we were abreast of the North Foreland, bearing E b S  $\frac{1}{2}$  S, distance  $1 \frac{1}{2}$  mile. Sounded in twenty fathom; rocky ground.

4th. Very little wind in the morning. At noon the latitude by observation was  $79^{\circ} 31'$ . Magdalena Hook bore N  $39^{\circ}$  E distant about four miles; which gives the latitude of that place  $79^{\circ} 34'$ ; the same as Fotherby observed it to be in 1614. Stood in to a small bay to the Southward of Magdalena and Hamburger's Bay: anchored with the stream anchor, and sent the boat for water. About three in the afternoon, when the boat was sent on shore, it appeared to be high water, and ebbed about three feet. This makes high water full and change at half an hour past one, or with a S S W moon; which agrees exactly with Baffin's observation in 1613. The flood comes from the Southward. Went ashore with the astronomer, and instruments, to observe the variation. A thick fog came on before we had completed the observations. The ship driving, I weighed and stood out to sea under an easy sail, firing guns frequently to show the Caravels where we were; and in

less than two hours joined her. Soon after, (about four in the morning of the 5th) the Rockingham Greenland Ship ran under our stern, and the master told me he had just spoke with some ships from which he learnt, that the ice was within ten leagues of Hacluyt's Head Land, to the North West. In consequence of this intelligence, I gave orders for steering in towards the Head Land; and if it should clear up, to steer directly for it; intending to go North from thence, till some circumstance should oblige me to alter my course.

5th. At five the officer informed me, that we were very near some islands off Dane's Gat, and that the pilot wished to stand farther out; I ordered the ship to be kept N b W, and hauled farther in, when clear of the islands. At noon I steered North, seeing nothing of the land; soon after I was told that they saw the ice: I went upon deck, and perceived something white upon the bow, and heard a noise like the surf upon the shore; I hauled down the studding sails, and hailed the Carcass to let them know that I should stand for it to make what it was, having all hands upon deck ready to haul up at a moment's warning: I desired that they would keep close to us, the fog being so thick, and have every body up ready to follow our motions instantaneously, determining to stand on under such sail as should enable us to keep the ships

ships under command, and not risk parting company. Soon after two small pieces of ice not above three feet square passed us, which we supposed to have floated from the shore. It was not long before we saw something on the bow, part black and part covered with snow, which from the appearance we took to be islands, and thought that we had not stood far enough out; I hauled up immediately to the N N W and was soon undeceived, finding it to be ice which we could not clear upon that tack; we tacked immediately, but the wind and sea both setting directly upon it, we neared it very fast, and were within little more than a cable's length of the ice, whilst in stays. The wind blowing fresh, the ships would have been in danger on the lee ice, had not the officers and men been very alert in working the ship. The ice, as far as we could then see, lay nearly E b N and W b S. At half past seven in the evening, the ship running entirely to the Southward, and the weather clearing a little, I tacked, and stood for the ice. When I saw it, I bore down to make it plain; at ten the ice lay from N W to East, and no opening. Very foggy, and little wind, all day; but not cold. At eleven came on a thick fog. At half past midnight, heard the surge of the ice, and hauled the wind to the Eastward.

6th. Clear weather all day, and the wind Easterly off the ice. In the morning I stood in to make the land plain. At six, was within four miles of the ice, which bore from ENE to WNW: at ten near Vogel Sang: at noon, latitude observed  $79^{\circ} 56' 39''$ ; wind Easterly. Continued plying to windward between the land and the ice: was within a quarter of a mile of the ice, which lay from ENE to NNW, when I tacked at two in the afternoon; and within half a cable's length at midnight; the Carcass was a great way astern and to leeward all day. Being so near the last rendezvous, I did not chuse to bring to for her, but was very anxious to avail myself of this favourable opportunity, having the wind off the ice and clear weather, to see whether there was any opening to the NE of the Head Land. By all the accounts from the Greenlandmen this year, and particularly the last account from the Rockingham, as well as from what we had seen ourselves, the ice appeared to be quite close to the NW. We had seen it from ESE to WNW. It was probable that the sea, if open any where, would be so to the Eastward, where the Greenlandmen do not often venture, for fear of being prevented from returning by the ice joining to Spitzbergen. I determined therefore, should the wind continue in the same quarter next day, to find whether the ice joined to the

the land, or was so detached as to afford me an opportunity of passing to the Eastward. In case of the ice being fast I could, with the wind Easterly, range close along the edge of it to the Westward. The weather exceedingly fine. At six in the afternoon, the longitude by the watch was  $9^{\circ} 43' 30''$  E.

7th. At five in the morning the wind was Northerly, and the weather remarkably clear. Being near the ice I ranged along it. It appeared to be close all round; but I was in hopes that some opening might be found to get through to a clear sea to the Northward. I ran in amongst the small ice, and kept as close as possible to the main body, not to miss any opening. At noon, Cloven Cliff  $W \frac{1}{2} S$  seven leagues. At one in the afternoon, being still amongst the loose ice, I sent the boat to one of the large pieces to fill water. At four we shoaled the water very suddenly to fourteen fathom: the outer part of Cloven Cliff bore  $W \frac{1}{2} N$ : Redcliff,  $S \frac{1}{2} E$ . The loose ice being open to the ENE, we hauled up, and immediately deepened our water to twenty-eight fathom; muddy ground, with shells. At half past four, the ice setting very close, we ran between two pieces, and having little wind were stopped. The Carcass being very near, and not answering her helm well, was almost on board of us. After getting clear of her, we ran



to the Eastward. Finding the pieces increase in number and size, and having got to a part less crowded with the drift ice, I brought to, at six in the evening, to see whether we could discover the least appearance of an opening: but it being my own opinion, as well as that of the pilots and officers, that we could go no farther, nor even remain there without danger of being beset, I sent the boat on board the Carcass for her pilots, to hear their opinion; they both declared that it appeared to them impracticable to proceed that way, and that it was probable we should soon be beset where we were, and detained there. The ice set so fast down, that before they got on board the Carcass we were fast. Captain Lutwidge hoisted our boat up, to prevent her being stove. We were obliged to heave the ship through for two hours, with ice anchors, from each quarter; nor were we quite out of the ice till midnight. This is about the place where most of the old discoverers were stopped. The people in both ships being much fatigued, and the Carcass not able to keep up with us, without carrying studding-sails, I shortened sail as soon as we were quite out, and left orders to stand to the Northward under an easy sail: I intended, having failed in this attempt, to range along the ice to the N W, in hopes of an opening that way, the wind being fair, and the weather clear; resolving, if I found it all solid, to return to the Eastward,

ward, where probably it might by that time be broken up, which the very mild weather encouraged me to expect.

8th. Little wind in the morning, and a swell setting on the ice, we were obliged to get the boats a-head, to tow the ship clear; which they effected with difficulty. A breeze springing up when we were within two cables lengths of the main body of the ice, stood in for the land, and attacked at two, to stand to the NW for the ice; but the weather coming thick between five and six, I stood in again for the land. It clearing up soon after, I bore away again NW for the ice. At ten, spoke with a Greenland Ship which had just left the ice all close to the NNW. Between eleven and twelve the wind came to the SW, with an heavy swell, and thick weather. Double-reefed the topsails, and tacked at twelve, to stand in for Hacluyt's Head Land, not thinking it proper to run in with the fast ice to leeward in thick weather, without even the probability of an opening; and proposing if that weather continued, to complete the ship's water, and be ready with the first wind, off or along the ice, to look out for an opening, and run in. To avoid any inconvenience which from the experience of the preceding day I perceived might happen, from too many running to one place on any sudden order, I divided the people into gangs under the midshipmen, and stationed them to the ice hooks, poles, crabs, and to go over upon the ice when wanted.

9th.

9th. Having a fair opportunity, and SW wind, stood to the Westward; intending, when the weather was clear, to make the ice to the Northward, and run along it. About twelve, clearer; saw the fast ice to the Northward, and the appearance of loose ice to the NW: stood directly for it, and got amongst it between two and three; steering as much to the Northward as the situation of the ice would permit. At six observed the dip  $81^{\circ} 52'$ . At half past seven, found the ice quite fast to the West, being in longitude  $2^{\circ} 2' E$ , by our reckoning, which was the farthest to the Westward of Spitsbergen that we got this voyage. At eight the fog was so very thick, that we could neither see which way to push for an opening, nor where the Carcass was, though very near us. That we might not risk parting company with her, I was obliged to ply to windward under the topails, tacking every quarter of an hour to keep in the opening in which we were, and clear of the ice which surrounded us. At four in the afternoon we were in  $80^{\circ} 36'$ .

10th. We lost the Carcass twice in the night, from the very thick fog, and were working all night amongst the ice, making very short tacks; the opening being small, and the floating ice very thick about the ship. The situation of the people from the very fatiguing work and wet weather, made the most minute precautions necessary for the preservation of their health: we now found the advantage

vantage of the spirits which had been allowed for extraordinary occasions; as well as the additional clothing furnished by the Admiralty. Notwithstanding every attention, several of the men were confined with colds, which affected them with pains in their bones; but, from the careful attendance given them, few continued in the sick list above two days at a time. At nine in the morning, when it cleared a little, we saw the Carcass much to the Southward of us. I took the opportunity of the clear weather to run to the Westward, and found the ice quite solid there; I then stood through every opening to the Northward, but there also soon got to the edge of the solid ice. I was forced to haul up to weather a point which ran out from it. After I had weathered that, the ice closing fast upon me, obliged me to set the foresail, which, with the fresh wind and smooth water, gave the ship such way as to force through it with a violent stroke. At one in the afternoon, immediately on getting out into the open sea, we found a heavy swell setting to the Northward; though amongst the ice, the minute before, the water had been as smooth as a mill pond. The wind blew strong at SSW. The ice, as far as we could see from the mast head, lay ENE: we steered that course close to it, to look for an opening to the Northward. I now began to conceive that the ice was one compact impenetrable body, having run along it from East to West above ten degrees. I purposed however

ever to stand over to the Eastward, in order to ascertain whether the body of ice joined to Spitzbergen. This the quantity of loose ice had before rendered impracticable; but thinking the Westerly winds might probably by this time have packed it all that way, I flattered myself with the hopes of meeting with no obstruction till I should come to where it joined the land; and in case of an opening, however small, I was determined at all events to push through it. The weather clearer, and the land in sight.

11th. At half past four in the morning the longitude by the lunar observation was  $9^{\circ} 42'$  E. And at the same time by my watch  $9^{\circ} 2'$  E. Cloven Cliff S S E, distant eight miles. This would make the longitude of Cloven Cliff  $9^{\circ} 38'$  E; which is within twenty minutes of what it was determined by the observations and survey taken in Fair Haven. At noon the latitude observed was  $80^{\circ} 4'$ ; Vogel Sang W S W. Little wind and a great swell in the morning. Calm most part of the day.

12th. Calm all day, with a great swell from the SW, and the weather remarkably mild. At eight in the evening longitude by the watch  $10^{\circ} 54' 30''$  E: Cloven Cliff S W b S. The Carcass drove with the current so near the main body of the ice, as to be obliged to anchor; she came to in twenty-six fathom water.

13th.

13th. Calm till noon, the ship driving to the Westward with the current, which we observed to be very irregular, the Carcass being driven at the same time to the Eastward. Near the main body of the ice, the detached pieces probably affect the currents, and occasion the great irregularity which we remarked. We had found an heavy swell from the S W these two days. At two in the afternoon it came on very suddenly to blow fresh from that quarter, with foggy weather: we worked into Vogel Sang, and anchored with the best bower in eleven fathom, soft clay.

The place where we anchored is a good roadstead, open from the N E to the N W. The Northeasternmost point is the Cloven Cliff, a bare rock so called from the top of it resembling a cloven hoof, which appearance it has always worn, having been named by some of the first Dutch navigators who frequented these seas. This rock being entirely detached from the other mountains, and joined to the rest of the island by a low narrow isthmus, preserves in all situations the same form; and being nearly perpendicular, it is never disguised by snow. These circumstances render it one of the most remarkable points on the coast. The Northwesternmost land is an high bluff point, called by the Dutch, Vogel Sang. This sound, though open to the Northward, is not liable to any inconvenience from that circumstance, the main  
body

body of the ice lying so near as to prevent any great sea; nor are ships in any danger from the loose ice setting in, as this road communicates with several others formed by different islands, between all which there are safe passages. To all the sounds and harbours formed by this knot of islands, the old English navigators had given the general name of Fair Haven; of which Fotherby took a *plat* in 1614: that in which the Racehorse and Carcass lay at this time they called the North Harbour; the harbour of Smeerenberg, distant about eleven miles, (in which we anchored in August) they named the South Harbour. Besides these, there are several others; particularly two, called, Cook's Hole, and the Norways, in both which several Dutch ships were lying at this time. Here the shore being steep-to, we completed our water with great ease, from the streams which fall in many places down the sides of the rocks, and are produced by the melting of the snow. I fixed upon a small flat island, or rock, about three miles from the ship, and almost in the center of those islands which form the many good roads here, as the properest place for erecting a tent, and making observations. The foggy weather on the 14th prevented us from using the instruments that day. I regretted this circumstance much, fearing it would deprive me of the only probable opportunity of making observations on shore in those high latitudes, as our water was nearly recruited:

however,

however, having little wind, with the weather very fair from the 15th to the 18th in the morning, I made the best use of that time. Even in the clearest weather here, the sky was never free from clouds, which prevented our seeing the moon during the whole of our stay, or even being sure of our solar observations, Mr. Lyons never having been able to get equal altitudes for settling the rates of going of the time-keepers. Once indeed we were fortunate enough to observe a revolution of the sun, of which I availed myself to determine the going of the pendulum adjusted to vibrate seconds at London. During the course of this experiment, a particular and constant attention was paid to the state of the thermometer, which I was surprised to find differ so little about noon and midnight; its greatest height was  $58^{\circ}\frac{1}{2}$ , at eleven in the forenoon; at midnight it was  $51^{\circ}$ .

On the 16th, at noon, the weather was remarkably fine and clear. The thermometer in the shade being at  $49^{\circ}$ , when exposed to the sun rose in a few minutes to  $89^{\circ}\frac{1}{2}$ , and remained so for some time, till a small breeze springing up, made it fall  $10^{\circ}$  almost instantly. The weather at this time was rather hot; so that I imagine, if a thermometer was to be graduated according to the feelings of people in these latitudes, the point of temperature would be about the 44th degree of Fahrenheit's scale. From this island I took a survey, to ascertain



ascertain the situation of all the points and openings, and the height of the most remarkable mountains: the longest base the island would afford was only 618 feet, which I determined by a cross base, as well as actual measurement, and found the results not to differ above three feet. To try how far the accuracy of this survey might be depended upon, I took in a boat, with a small Hadley's sextant, the angles between seven objects, which intersected exactly when laid down upon the plan. I had a farther proof of its accuracy some days after, by taking the bearings of Vogel Sang and Hacluyt's Head Land in one, which corresponded exactly with their position on my chart.

On the 17th, the weather being very clear, I went up one of the hills, from which I could see several leagues to the N E: the ice appeared uniform and compact, as far as my view extended. During our stay here, we found the latitude of the island on which the observations were made, to be  $79^{\circ} 50'$ ; longitude  $10^{\circ} 2' 30''$  E; variation  $20^{\circ} 38' W$ ; dip  $82^{\circ} 7'$ : latitude of Cloven Cliff  $79^{\circ} 53'$ ; longitude  $9^{\circ} 59' 30''$  E: Hacluyt's Head Land  $79^{\circ} 47'$ ; longitude  $9^{\circ} 11' 30''$  E. The tide rose about four feet, and flowed at half an hour after one, full and change. The tide set irregularly, from the number of islands between which it passed; but the flood appeared to come from the Southward.

18th. The calm weather since the 14th had given us full time to finish the observations, and complete our water: a breeze springing up in the morning, I went ashore to get the instruments on board. Between one and two we weighed, with the wind Westerly, and stood to the Northward. Between eleven and twelve at night, having run about eight leagues, we were prevented by the ice from getting farther. We stood along the edge of it to the Southward. At two in the morning, being embayed by the ice, I tacked, and left orders to stand to the Eastward along the edge of the ice, as soon as we could weather the point; hoping, if there should be no opening between the land and the ice, that I should at least be able to ascertain where they joined, and perhaps to discover from the land, whether there was any prospect of a passage that way: At that time the ice was all solid as far as we could see, without the least appearance of water to the Northward.

19th. At six in the morning we had got to the Eastward among the loose ice which lay very thick in shore, the main body to the Northward and Eastward: the land near Deer Field not four miles off, and the water shoaled to twenty fathoms. Here we found ourselves nearly in the same place where we had twice been stopped, the ice situated as before, locked with the land, without any passage either to the Eastward or Northward: I therefore  
E
stood

stood back to the Westward. At noon the Northernmost part of Vogel Sang bore S W b S, distant about seven leagues. The weather being very fine, and the wind to the Eastward, we were enabled to coast along the ice to the Westward, hauling into all the bays, going round every point of ice in search of an opening, and standing close along by the main body all day, generally within a ship's length.

20th. At half after three in the morning the land was out of sight, and we imagined ourselves in rather more than eighty degrees and an half; some of the openings being near two leagues deep, had flattered us with hopes of getting to the Northward; but these openings proved to be no more than bays in the main body of the ice. About one in the afternoon, we were by our reckoning in about  $80^{\circ} 34'$ , nearly in the same place where we had been on the 9th. About three we bore away for what appeared like an opening to the S W; we found the ice run far to the Southward.

21st. We still continued to run along the edge of the ice, which trended to the Southward. At noon we were in the latitude of  $79^{\circ} 26'$ , by observation, which was twenty-five miles to the Southward of our reckoning. Finding that the direction of the ice led us to the Southward, and that the current set the same way, I stood to the Northward and Westward close along the ice, to try whether the

sea was opened to the Northward by the wind from that quarter. At nine in the evening we had no ground with 200 fathom of line. At ten we got into a stream of loose ice. The weather fine, but cool all day, and sometimes foggy.

22d. At two in the morning we bore away to the N E, for the main body of the ice; the weather became foggy soon afterwards. At six we saw the ice; and the weather being still foggy, we hauled up to the S S E, to avoid being embayed in it. The air very cold.

23d. At midnight, tacked for the body of the ice. Latitude observed  $80^{\circ} 13' 38''$ . Rainy in the morning; fair in the afternoon: still working up to the Northward and Eastward, with the wind Easterly. At six in the evening, the Cloven Cliff bearing South about six leagues, sounded in 200 fathom, muddy ground; the lead appeared to have sunk one third of its length in the mud. At two in the morning, with little wind, and a swell from the South West, I stood to the Northward amongst the loose ice: at half past two the main body of the ice a cable's length off, and the loose ice so close that we wore ship, not having room or way enough to tack; struck very hard against the ice in getting the ship round, and got upon one piece, which lifted her in the water for near a minute, before her weight broke it. The ships had

been so well strengthened, that they received no damage from these strokes; and I could with the more confidence push through the loose ice, to try for openings. Hacluyt's Head Land bore S 50° W distant about seven leagues.

24th. By this situation of the ice we were disappointed of getting directly to the Northward, without any prospect after so many fruitless attempts of being able to succeed to the Westward; nor indeed, could I with an Easterly wind and heavy swell attempt it, as the wind from that quarter would not only pack the loose ice close to the Westward, but by setting the sea on it, make it as improper to be approached as a rocky lee shore. To the Eastward on the contrary it would make smooth water, and detach all the loose ice from the edges; perhaps break a stream open, and give us a fair trial to the Northward; at all events, with an Easterly wind we could run out again, if we did not find it practicable to proceed. Finding the ice so fast to the Northward and Westward, it became a desirable object to ascertain how far it was possible to get to the Eastward, and by that means pursue the voyage to the Northward. These considerations determined me to ply to the Eastward, and make another push to get through where I had been three times repulsed. In working to the Eastward, we kept as near the body of the ice as possible. At noon the Cloven Cliff bore SW by S about

about seven leagues. At six we were working to the NE, and at nine we steered to the SE, the ice appearing more open that way: we had fresh gales and cloudy weather. The ship struck very hard in endeavouring to force through the loose ice. At midnight the wind freshened, and we double reefed the topsails. It was probably owing to the fresh gales this day, as well as to the summer being more advanced, that we were enabled to get farther than in any of our former attempts this way. We continued coasting the ice, and at two in the morning the north part of Vogel Sang and Hacluyt's Head Land in one bore S 65° W; Cloven Cliff S 52° W; the nearest part of the shore about three leagues off. When I left the deck, at four in the morning, we were very near the spot where the ships had been fast in the ice on the 7th in the evening, but rather farther to the Eastward; we had passed over the same shoal water we had met with that day, and were now in twenty fathom, rocky ground; still amongst loose ice, but not so close as we had hitherto found it.

25th. At seven in the morning we had deepened our water to fifty-five fathom, and were still amongst the loose ice. At noon we had deepened our water to seventy fathom, with muddy bottom, at the distance of about three miles from the nearest land. By two in the afternoon we had passed Deer Field, which we had so often before at-

tempted without success; and finding the sea open to the NE, had the most flattering prospect of getting to the Northward. From this part, all the way to the Eastward, the coast wears a different face; the mountains, though high, are neither so steep or sharp-pointed, nor of so black a colour as to the Westward. It was probably owing to this remarkable difference in the appearance of the shore, that the old navigators gave to places hereabouts the names of *Red Beach*, *Red Hill*, and *Red Cliff*. One of them, speaking of this part, has described the whole country in a few words: "Here" (says he) "I saw a more natural earth and clay than any that I have seen in all the country, but nothing growing thereupon more than in other places." At two in the afternoon we had little wind, and were in sight of Moffen Island, which is very low and flat.

The Carcass being becalmed very near the island in the evening, Captain Lutwidge took that opportunity of obtaining the following exact account of its extent, which he communicated to me.

"At 10 P M, the body of Moffen Island bearing E b S distant two miles; founded thirteen fathoms; rocky ground, with light brown mud, and broken shells. Sent the master on shore, who found the island to be nearly of a round form, about two miles in diameter, with a lake  
" or

“ or large pond of water in the middle, all frozen  
 “ over, except thirty or forty yards round the edge  
 “ of it, which was water, with loose pieces of  
 “ broken ice, and so shallow they walked through  
 “ it, and went over upon the firm solid ice. The  
 “ ground between the sea and the pond is from  
 “ half a cable’s length to a quarter of a mile broad,  
 “ and the whole island covered with gravel and  
 “ small stones, without the least verdure or vege-  
 “ tation of any kind. They saw only one piece of  
 “ drift wood (about three fathom long, with a root  
 “ on it, and as thick as the Carcass’s mizen mast)  
 “ which had been thrown up over the high part of  
 “ the land, and lay upon the declivity towards the  
 “ pond. They saw three bears, and a number of  
 “ wild ducks, geese, and other sea fowls, with  
 “ birds nests all over the island. There was an in-  
 “ scription over the grave of a Dutchman, who  
 “ was buried there in July 1771. It was low water  
 “ at eleven o’clock when the boat landed, and the  
 “ tide appeared to flow eight or nine feet; at that  
 “ time we found a current carrying the Ship to the  
 “ N W from the island, which before carried us to  
 “ the S E (at the rate of a mile an hour) towards  
 “ it. On the West side is a fine white sandy bottom,  
 “ from two fathoms, at a ship’s length from the  
 “ beach, to five fathoms, at half a mile’s distance  
 “ off.”

The soundings all about this island, and to the Eastward, seem to partake of the nature of the



coast. To the Westward the rocks were high, and the shores bold and steep too; here the land shelved more, and the soundings were shoal, from thirty to ten fathom. It appears extraordinary that none of the old navigators, who are so accurate and minute in their descriptions of the coast, have taken any notice of this island, so remarkable and different from every thing they had seen on the Western coast; unless we should suppose that it did not then exist, and that the streams from the great ocean up the West side of Spitzbergen, and through the Waygat's Straits, meeting here, have raised this bank, and occasioned the quantity of ice that generally blocks up the coast hereabouts.—At four in the afternoon, hoisted out the boat, and tried the current, which set N E b E, at the rate of three quarters of a mile an hour. At midnight, Moffen Island bore from S E' b S to S b W, distant about five miles.

26th. About two in the morning, we had little wind, with fog; made the signals to the Carcass for keeping company. At half an hour after three in the afternoon, we were in longitude  $12^{\circ} 20' 45''$  E; variation, by the mean of five azimuths,  $12^{\circ} 47'$  W. At nine we saw land to the Eastward; steering to the Northward with little wind, and no ice in sight, except what we had passed.

27th.

27th. Working still to the N E, we met with some loose ice; however from the openness of the sea hitherto, since we had passed Deer Field, I had great hopes of getting far to the Northward; but about noon, being in the latitude of eighty and forty-eight, by our reckoning, we were stopped by the main body of the ice, which we found lying in a line, nearly East and West, quite solid. Having tacked, I brought to, and sounded close to the edge of the ice, in 79 fathom, muddy bottom.

The wind being still Easterly, I worked up close to the edge of the ice, coasting it all the way. At six in the evening we were in longitude  $14^{\circ} 59' 30''$  E, by observation.

28th. At midnight the latitude observed was  $80^{\circ} 37'$ . The main body of the ice still lying in the same direction, we continued working to the Eastward, and found several openings to the Northward, of two or three miles deep; into every one of which we ran, forcing the ship, wherever we could, by a press of sail, amongst the loose ice which we found here in much larger pieces than to the Westward. At six in the morning the variation, by the mean of six azimuths, was  $11^{\circ} 56' W$ ; the horizon remarkably clear. At noon, being close to the main body of the ice, the latitude by observation was  $80^{\circ} 36'$ : we sounded in 101 fathom, muddy ground. In the afternoon the wind blew fresh at N E, with a thick fog;

fog; the ice hung much about the rigging. The loose ice being thick and close, we found ourselves so much engaged in it, as to be obliged to run back a considerable distance to the Westward and Southward, before we could extricate ourselves: we afterwards had both the sea and the weather clear, and worked up to the North Eastward. At half past five the longitude of the ship was  $15^{\circ} 16' 45''$  E. At seven the Easternmost land bore E  $\frac{1}{2}$  N distant about seven or eight leagues, appearing like deep bays and islands, probably those called in the Dutch charts the *Seven Islands*; they seemed to be surrounded with ice. I stood to the Southward, in hopes of getting to the Southeastward round the ice, and between it and the land, where the water appeared more open.

29th. At midnight the latitude by observation was  $80^{\circ} 21'$ . At four, tacked close to the ice, hauled up the foresail and backed the mizen top-sail, having too much way amongst the loose ice. At noon, latitude observed  $80^{\circ} 24' 56''$ . An opening, which we supposed to be the entrance of Waygat's Straits, bore South; the Northernmost land N E b E; the nearest shore distant about four miles. In the afternoon the officer from the deck came down to tell me, we were very near a small rock even with the water's edge; on going up, I saw it within little more than a ship's length on the lee bow, and put the helm down: before the ship  
got

got round, we were close to it, and perceived it to be a very small piece of ice, covered with gravel. In the evening, seeing the Northern part of the islands only over the ice, I was anxious to get round it, in hopes of finding an opening under the land. Being near a low flat island opposite the Waygat's Straits, not higher, but much larger than Moffen Island, we had an heavy swell from the Southward, with little wind, and from ten to twenty fathom: having got past this island, approaching to the high land to the Eastward, we deepened our water very suddenly to 117 fathom. Having little wind, and the weather very clear, two of the officers went with a boat in pursuit of some sea-horses, and afterwards to the low island. At midnight we found by observation the latitude  $80^{\circ} 27' 3''$ , and the dip  $82^{\circ} 2' \frac{1}{2}$ . At four in the morning I found, by Bouguer's log, that the current set two fathom to the Eastward. At six in the morning the officers returned from the island; in their way back they had fired at, and wounded a sea-horse, which dived immediately, and brought up with it a number of others. They all joined in an attack upon the boat, wrested an oar from one of the men, and were with difficulty prevented from staving or over-setting her: but a boat from the Carcass joining ours, they dispersed. One of that ship's boats had before been attacked in the same manner off Moffen Island. From Dr. Irving, who went on this party, I had the following account of the low island.

“ We

“ We found several large fir trees lying on the  
“ shore, sixteen or eighteen feet above the level  
“ of the sea : some of these trees were seventy feet  
“ long, and had been torn up by the roots ; others  
“ cut down by the axe, and notched for twelve  
“ feet lengths : this timber was no ways decayed,  
“ or the strokes of the hatchet in the least effaced.  
“ There were likewise some pipe-staves, and wood  
“ fashioned for use. The beach was formed of  
“ old timber, sand, and whale-bones.

“ The island is about seven miles long, flat, and  
“ formed chiefly of stones from eighteen to thirty  
“ inches over, many of them hexagons, and com-  
“ modiously placed for walking on : the middle  
“ of the island is covered with moss, scurvy grass,  
“ sorrel, and a few ranunculuses then in flower.  
“ Two rein-deer were feeding on the moss ; one  
“ we killed, and found it fat, and of high flavour.  
“ We saw a light grey-coloured fox ; and a creature  
“ somewhat larger than a weasel, with short ears,  
“ long tail, and skin spotted white and black. The  
“ island abounds with small snipes, similar to the  
“ jack-snipe in England. The Ducks were now  
“ hatching their eggs, and many wild geese feeding  
“ by the water side.”

When I left the deck at six in the morning, the  
weather was remarkably clear, and quite calm.  
To the N E, amongst the islands, I saw much ice,  
but also much water between the pieces ; which  
gave

gave me hopes. that when a breeze sprung up, I should be able to get to the Northward by that way.

30th. Little winds, and calm all day ; we got something to the Northward and Eastward. At noon we were by observation in latitude  $80^{\circ} 31'$ . At three in the afternoon we were in longitude  $18^{\circ} 48'$  E, being amongst the islands, and in the ice, with no appearance of an opening for the ship. Between eleven and twelve at night I sent the master, Mr. Crane, in the four-oared boat, amongst the ice, to try whether he could get the boat through, and find any opening for the ship which might give us a prospect of getting farther ; with directions if he could reach the shore to go up one of the mountains, in order to discover the state of the ice to the Eastward and Northward. At five in the morning, the ice being all round us, we got out our ice-anchors, and moored along-side a field. The master returned between seven and eight, and with him Captain Lutwidge, who had joined him on shore. They had ascended an high mountain, from whence they commanded a prospect extending to the East and North East ten or twelve leagues, over one continued plain of smooth unbroken ice, bounded only by the horizon : they also saw land stretching to the S E, laid down in the Dutch Charts as islands. The main body of ice, which we had traced from West to East, they now perceived to join to these islands, and from them to  
what

what is called the North East land. In returning, the ice having closed much since they went, they were frequently forced to haul the boat over it to other openings. The weather exceedingly fine and mild, and unusually clear. The scene was beautiful and picturesque; the two ships becalmed in a large bay, with three apparent openings between the islands which formed it, but every-where surrounded with ice as far as we could see, with some streams of water; not a breath of air; the water perfectly smooth; the ice covered with snow, low, and even, except a few broken pieces near the edges: the pools of water in the middle of the pieces were frozen over with young ice.

31st. At nine in the morning, having a light breeze to the Eastward, we cast off, and endeavoured to force through the ice. At noon the ice was so close, that being unable to proceed, we moored again to a field. In the afternoon we filled our cask with fresh water from the ice, which we found very pure and soft. The Carcass moved, and made fast to the same field with us. The ice measured eight yards ten inches in thickness at one end, and seven yards eleven inches at the other. At four in the afternoon the variation was  $12^{\circ} 24'$  W: at the same time the longitude  $19^{\circ} 0' 15''$  E; by which we found that we had hardly moved to the Eastward since the day before. Calm most part of the day; the weather very fine; the ice closed

closed fast, and was all round the ships; no opening to be seen any where, except an hole of about a mile and a half, where the ships lay fast to the ice with ice-anchors. We completed the water. The ship's company were playing on the ice all day. The pilots being much farther than they had ever been, and the season advancing, seemed alarmed at being beset.

August 1st. The ice pressed in fast; there was not now the smallest opening; the two ships were within less than two lengths of each other, separated by ice, and neither having room to turn. The ice, which had been all flat the day before, and almost level with the water's edge, was now in many places forced higher than the main yard, by the pieces squeezing together. Our latitude this day at noon, by the double altitude, was  $80^{\circ} 37'$ .

2d. Thick foggy wet weather, blowing fresh to the Westward; the ice immediately about the ships rather looser than the day before, but yet hourly setting in so fast upon us, that there seemed to be no probability of getting the ships out again, without a strong East, or North East wind. There was not the smallest appearance of open water, except a little towards the West point of the North East land. The seven islands and North East land, with the frozen sea, formed almost a basin, leaving but about four points opening for the ice to drift out, in case of a change of wind.



3d. The weather very fine, clear, and calm; we perceived that the ships had been driven far to the Eastward; the ice was much closer than before, and the passage by which we had come in from the Westward closed up, no open water being in sight, either in that or any other quarter. The pilots having expressed a wish to get if possible farther out, the ships companies were set to work at five in the morning, to cut a passage through the ice, and warp through the small openings to the Westward. We found the ice very deep, having sawed sometimes through pieces twelve feet thick. This labour was continued the whole day, but without any success; our utmost efforts not having moved the ships above three hundred yards to the Westward through the ice, at the same time that they had been driven (together with the ice itself, to which they were fast) far to the NE and Eastward, by the current; which had also forced the loose ice from the Westward, between the islands, where it became packed, and as firm as the main body.

4th. Quite calm till evening, when we were flattered with a light air to the Eastward, which did not last long, and had no favourable effect. The wind was now at NW, with a very thick fog, the ship driving to the Eastward. The pilots seemed to apprehend that the ice extended very far to the Southward and Westward.

5th.

5th. The probability of getting the ships out appearing every hour less, and the season being already far advanced, some speedy resolution became necessary as to the steps to be taken for the preservation of the people. As the situation of the ships prevented us from seeing the state of the ice to the Westward, by which our future proceedings must in a great measure be determined, I sent Mr. Walden, one of the midshipmen, with two pilots, to an island about twelve miles off, which I have distinguished in the charts by the name of Walden's Island, to see where the open water lay.

6th. Mr. Walden and the pilots, who were sent the day before to examine the state of the ice from the island, returned this morning with an account, that the ice, though close all about us, was open to the Westward, round the point by which we came in. They also told me, that when upon the island they had the wind very fresh to the Eastward, though where the ships lay it had been almost calm all day. This circumstance considerably lessened the hopes we had hitherto entertained of the immediate effect of an Easterly wind in clearing the bay. We had but one alternative; either patiently to wait the event of the weather upon the ships, in hopes of getting them out, or to betake ourselves to the boats. The ships had driven into shoal water, having but fourteen fathom. Should they, or the ice to which they were fast, take the  
F ground,

ground, they must be inevitably lost, and probably overfet. The hopes of getting the ships out was not hastily to be relinquished, nor obstinately adhered to, till all other means of retreat were cut off. Having no harbour to lodge them in, it would be impossible to winter them here, with any probability of their being again serviceable; our provisions would be very short for such an undertaking, were it otherwise feasible; and supposing, what appeared impossible, that we could get to the nearest rocks, and make some conveniences for wintering, being now in an unfrequented part, where ships never even attempt to come, we should have the same difficulties to encounter the next year, without the same resources; the remains of the ship's company, in all probability, not in health; no provisions; and the sea not so open, this year having certainly been uncommonly clear. Indeed it could not have been expected that more than a very small part should survive the hardships of such a winter with every advantage; much less in our present situation. On the other hand, the undertaking to move so large a body for so considerable a distance by boats, was not without very serious difficulties. Should we remain much longer here, the bad weather must be expected to set in. The stay of the Dutchmen to the Northward is very doubtful: if the Northern harbours keep clear, they stay till the beginning of September; but when the loose ice sets in, they quit them immediately. I thought it  
proper

proper to send for the officers of both ships, and informed them of my intention of preparing the boats for going away. I immediately hoisted out the boats, and took every precaution in my power to make them secure and comfortable: the fitting would necessarily take up some days. The water shoaling, and the ships driving fast towards the rocks to the N E, I ordered canvass bread-bags to be made, in case it should be necessary very suddenly to betake ourselves to the boats: I also sent a man with a lead and line to the Northward, and another from the Carcass to the Eastward, to sound wherever they found cracks in the ice, that we might have notice before either the ships, or the ice to which they were fast, took the ground; as in that case, they must instantly have been crushed or overfet. The weather bad; most part of the day foggy, and rather cold.

7th. In the morning I set out with the Launch over the ice; she hauled much easier than I could have expected; we got her about two miles. I then returned with the people for their dinner. Finding the ice rather more open near the ships, I was encouraged to attempt moving them. The wind being Easterly; though but little of it, we set the sails, and got the ships about a mile to the Westward. They moved indeed, but very slowly, and were not now by a great deal so far to the Westward as where they were beset. However, I

kept all the sail upon them, to force through whenever the ice slackened the least. The people behaved very well in hauling the boat; they seemed reconciled to the idea of quitting the ships, and to have the fullest confidence in their officers. The boats could not with the greatest diligence be got to the water side before the fourteenth; if the situation of the ships did not alter by that time, I should not be justified in staying longer by them. In the mean time I resolved to carry on both attempts together, moving the boats constantly, but without omitting any opportunity of getting the ships through.

8th. At half past four, sent two pilots with three men to see the state of the ice to the Westward, that I might judge of the probability of getting the ships out. At nine they returned, and reported the ice to be very heavy and close, consisting chiefly of large fields. Between nine and ten this morning, I set out with the people, and got the Launch above three miles. The weather being foggy, and the people having worked hard, I thought it best to return on board between six and seven. The ships had in the mean time moved something through the ice, and the ice itself had drifted still more to the Westward. At night there was little wind, and a thick fog, so that I could not judge precisely of the advantage we had gained; but I still feared that, however flattering, it was not such as to justify  
my

my giving up the idea of moving the boats, the season advancing so fast, the preservation of the ships being so uncertain, and the situation of the people so critical.

9th. A thick fog in the morning: we moved the ship a little through some very small openings. In the afternoon, upon its clearing up, we were agreeably surprized to find the ships had driven much more than we could have expected to the Westward. We worked hard all day, and got them something more to the Westward through the ice; but nothing in comparison to what the ice itself had drifted. We got past the Launches; I sent a number of men for them, and got them on board. Between three and four in the morning the wind was Westerly, and it snowed fast. The people having been much fatigued, we were obliged to desist from working for a few hours. The progress which the ships had made through the ice was, however, a very favourable event: the drift of the ice was an advantage that might be as suddenly lost, as it had been unexpectedly gained, by a change in the current: we had experienced the inefficacy of an Easterly wind when far in the bay, and under the high land; but having now got through so much of the ice, we began again to conceive hopes that a brisk gale from that quarter would soon effectually clear us.

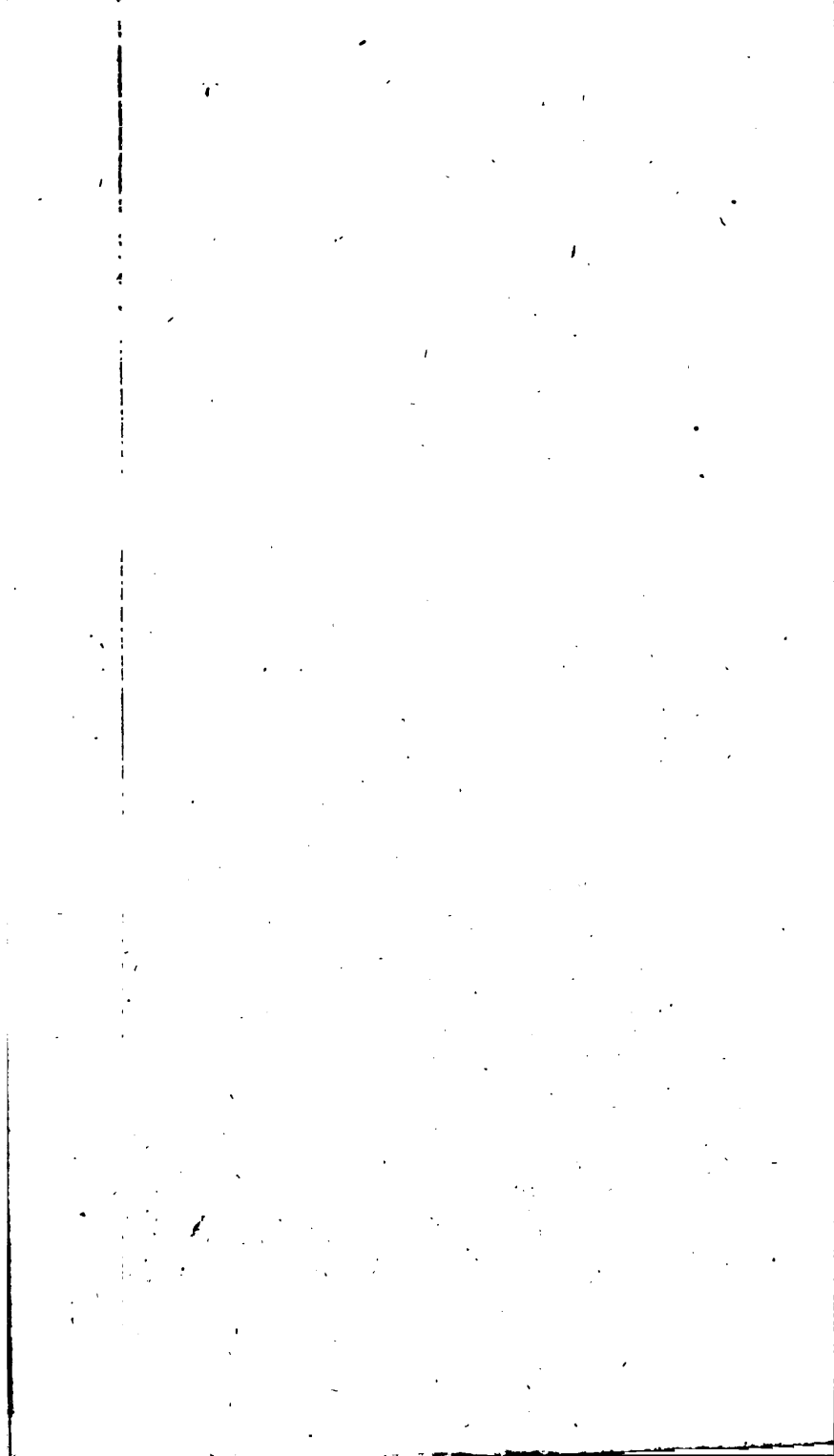
10th. The wind springing up to the NNE in the morning, we set all the sail we could upon the ship, and forced her through a great deal of very heavy ice: she struck often very hard, and with one stroke broke the shank of the best bower anchor. About noon we had got her through all the ice, and out to sea. I stood to the NW to make the ice, and found the main body just where we left it. At three in the morning, with a good breeze Easterly, we were standing to the Westward, between the land and the ice, both in sight; the weather hazy.

11th. Came to an anchor in the harbour of Smeerenberg, to refresh the people after their fatigues. We found here four of the Dutch ships, which we had left in the Norways when we sailed from Vogel Sang, and upon which I had depended for carrying the people home in case we had been obliged to quit the ships. In this Sound there is good anchorage in thirteen fathom, sandy bottom, not far from the shore: it is well sheltered from all winds. The island close to which we lay is called Amsterdam Island, the Westernmost point of which is Hacluyt's Head Land: here the Dutch used formerly to boil their whale-oil, and the remains of some conveniencies erected by them for that purpose are still visible. Once they attempted to make an establishment, and left some people to winter here, who all perished. The Dutch ships  
still



*the ICE, August, 10, 1773.*





still resort to this place for the latter season of the whale fishery.

12th. Got the instruments on shore, and the tent pitched; but could not make any observations this day or the next, from the badness of the weather.

13th. Rain, and blowing hard: two of the Dutch ships sailed for Holland.

14th. The weather being fine and little wind, we began our observations.

18th. Completed the observations. Calm all day. During our stay, I again set up the pendulum, but was not so fortunate as before, never having been able to get an observation of a revolution of the sun, or even equal altitudes for the time. We had an opportunity of determining the refraction at midnight, which answered within a few seconds to the calculation in Dr. Bradley's table, allowing for the barometer and thermometer. Being within sight of Cloven Cliff, I took a survey of this part of Fair Haven, to connect it with the plan of the other part. Dr. Irving climbed up a mountain, to take its height with the barometer, which I determined at the same time geometrically with great care. By repeated observations here we found the latitude to be  $79^{\circ} 44'$ , which by the survey corresponded exactly with the latitude of Cloven Cliff, determined before; the longitude  $9^{\circ} 50' 45''$  E; dip  $82^{\circ} 8' 4''$ ; variation  $18^{\circ} 57'$  W; which agrees also with

the observation made on shore in July. The tide flowed here half past one, the same as in Vogel Sang harbour.

Opposite to the place where the instruments stood, was one of the most remarkable Icebergs in this country. Icebergs are large bodies of ice filling the vallies between the high mountains; the face towards the sea is nearly perpendicular, and of a very lively light green colour. This was about three hundred feet high, with a cascade of water issuing out of it. The black mountains, white snow, and beautiful colour of the ice, make a very romantick and uncommon picture. Large pieces frequently break off from the Icebergs, and fall with great noise into the water: we observed one piece which had floated out into the bay, and grounded in twenty-four fathom; it was fifty feet high above the surface of the water, and of the same beautiful colour as the Iceberg.

A particular description of all the plants and animals will have a place in the Appendix. I shall here mention such general observations as my short stay enabled me to make. The stone we found was chiefly a kind of marble, which dissolved easily in the marine acid. We perceived no marks of minerals of any kind, nor the least appearance of present, or remains of former Volcanoes. Neither did we meet with insects, or any species of reptiles; not even the common earthworm. We saw no springs or rivers, the water, which we found

found in great plenty, being all produced by the melting of the snow from the mountains. During the whole time we were in these latitudes, there was no thunder or lightning. I must also add, that I never found what is mentioned by Marten (who is generally accurate in his observations, and faithful in his accounts) of the sun at midnight resembling in appearance the moon; I saw no difference in clear weather between the sun at midnight and any other time, but what arose from a different degree of altitude; the brightness of the light appearing there, as well as elsewhere, to depend upon the obliquity of his rays. The sky was in general loaded with hard white clouds; so that I do not remember to have ever seen the sun and the horizon both free from them even in the clearest weather. We could always perceive when we were approaching the ice, long before we saw it, by a bright appearance near the horizon, which the pilots called the *blink of the ice*. Hudson remarked, that the sea where he met with ice was blue; but the green sea was free from it. I was particularly attentive to observe this difference, but could never discern it.

The Driftwood in these seas has given rise to various opinions and conjectures, both as to its nature and the place of its growth. All that which we saw (except the pipe-staves taken notice of by Doctor Irving on the Low Island) was fir, and not worm-eaten. The place of its growth I had no opportunity of ascertaining. The

The nature of the ice was a principal object of attention in this climate. We found always a great swell near the edge of it; but whenever we got within the loose ice, the water was constantly smooth. The loose fields and flaws, as well as the interior part of the fixed ice, were flat, and low: with the wind blowing on the ice, the loose parts were always, to use the phrase of the Greenlanders, *packed*; the ice at the edges appearing rough and piled up; this roughness and height I imagine to proceed from the smaller pieces being thrown up by the force of the sea on the solid part. During the time that we were fast amongst the Seven Islands, we had frequent opportunities of observing the irresistible force of the large bodies of floating ice. We have often seen a piece of several acres square lifted up between two much larger pieces, and as it were becoming one with them; and afterwards this piece so formed acting in the same manner upon a second and third; which would probably have continued to be the effect, till the whole bay had been so filled with ice that the different pieces could have had no motion, had not the stream taken an unexpected turn, and set the ice out of the bay.

19th. Weighed in the morning with the wind at NNE. Before we got out of the bay it fell calm. I observed for these three or four days, about eleven in the evening, an appearance of dusk.

20th.

20th. At midnight, being exactly in the latitude of Cloven Cliff, Mr. Harvey took an observation for the refraction; which we found to agree with the tables. The wind Southerly all day, blowing fresh in the afternoon. About noon fell in with a stream of loose ice, and about four made the main ice near us. We stood to the W N W. along it at night, and found it in the same situation as when we saw it before; the wind freshened and the weather grew thick, so that we lost sight of it, and could not venture to stand nearer, the wind being S S W.

21st. At two in the morning we were close in with the body of the West ice, and obliged to tack for it; blowing fresh, with a very heavy sea from the Southward. The wind abated in the afternoon, but the swell continued, with a thick fog.

22d. The wind sprung up Northerly, with a thick fog; about noon moderate and clearer; but coming on to blow fresh again in the evening, with a great sea, and thick fog, I was forced to haul more to the Eastward, lest we should be embayed, or run upon lee ice.

The season was so very far advanced, and fogs as well as gales of wind so much to be expected, that nothing more could now have been done, had any thing been left untried. The summer appears to have been uncommonly favourable for our purpose,

purpose, and afforded us the fullest opportunity of ascertaining repeatedly the situation of that wall of ice, extending for more than twenty degrees between the latitudes of eighty and eighty-one, without the smallest appearance of any opening.

I should here conclude the account of the voyage, had not some observations and experiments occurred on the passage home.

In steering to the Southward we soon found the weather grow more mild, or rather to our feelings warm. August 24th, we saw Jupiter: the sight of a star was now become almost as extraordinary a phenomenon, as the sun at midnight when we first got within the Arctic circle. The weather was very fine for some part of the voyage; on the 4th of September, the water being perfectly smooth with a dead calm, I repeated with success the attempt I had made to get soundings in the main ocean at great depths, and struck ground in six hundred and eighty-three fathoms, with circumstances (which will be mentioned in the Appendix) that convince me I was not mistaken in the depth; the bottom was a fine soft blue clay. From the 7th of September, when we were off Shetland, till the 24th, when we made Orfordness, we had very hard gales of wind with little intermission, which were constantly indicated several hours before they came on by the fall of the barometer, and rise of the manometer: this proved to me the utility

utility of those instruments at sea. In one of these gales, the hardest, I think, I ever was in, and with the greatest sea, we lost three of our boats, and were obliged to heave two of our guns overboard, and bear away for some time, though near a lee shore, to clear the ship of water. I cannot omit this opportunity of repeating, that I had the greatest reason on this, as well as every other critical occasion, to be satisfied with the behaviour both of the officers and seamen. In one of these gales on the 12th of September, Dr. Irving tried the temperature of the sea in that state of agitation, and found it considerably warmer than that of the atmosphere. This observation is the more interesting, as it agrees with a passage in Plutarch's *Natural Questions*, not (I believe) before taken notice of, or confirmed by experiment, in which he remarks, "that the sea becomes warmer by being agitated in waves."

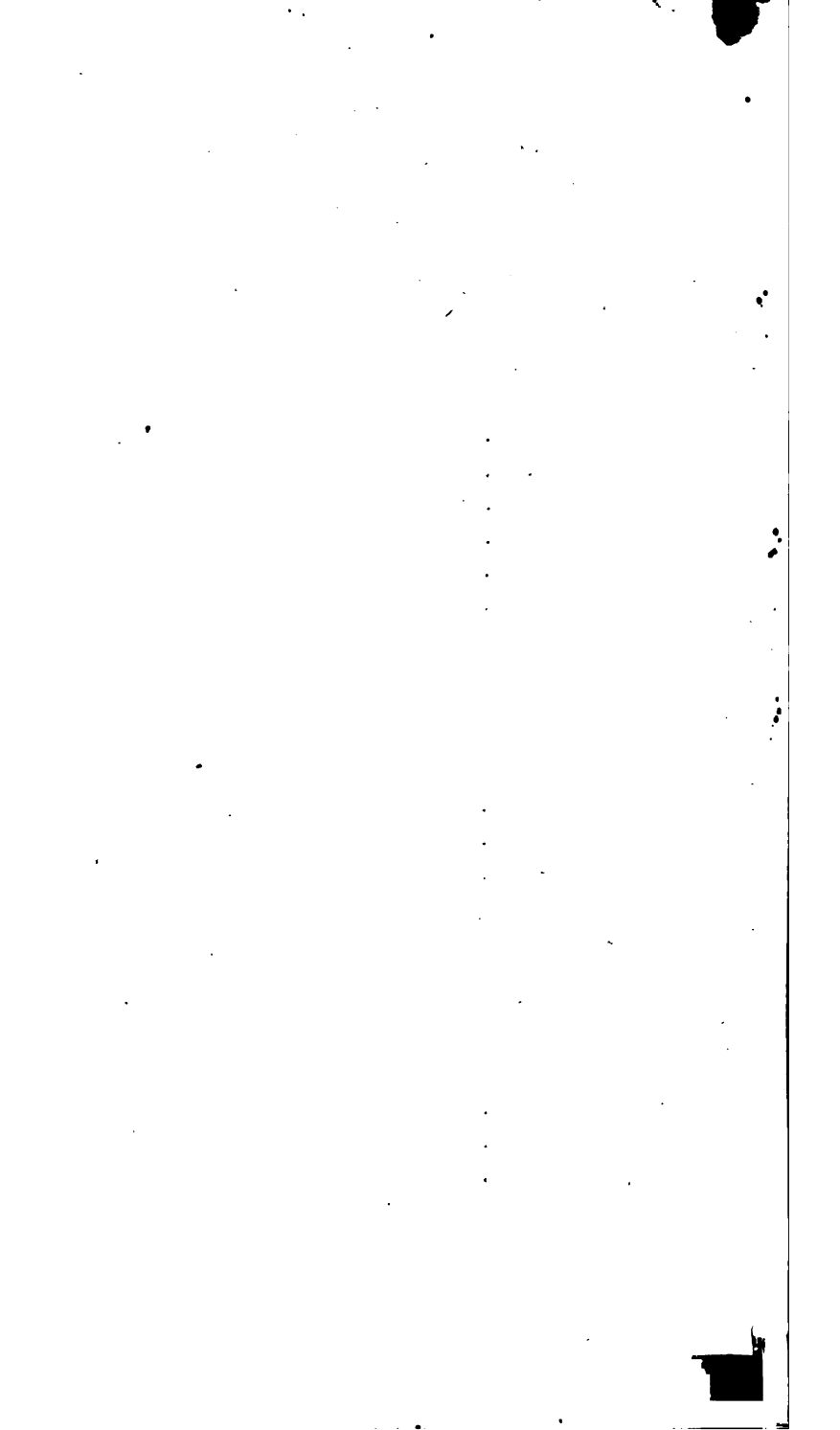
The frequent and very heavy gales at the latter end of the year, confirmed me in the opinion, that the time of our sailing from England was the properest that could have been chosen. These gales are as common in the Spring as in the Autumn: there is every reason to suppose therefore, that at an early season we should have met with the same bad weather in going out as we did on our return. The unavoidable necessity of carrying a quantity of additional stores and provisions, rendered the ships so deep in the water, that in heavy gales the boats, with many of the stores, must probably



Comparative Table of the Latitudes and Longitudes of some remarkable Places.

| Places.              | By Sir Jonas Moore. |            | By the Atlas Maritimus. |            | By Robertfon's Navigation. |            | By Observations made this Voyage. |            |
|----------------------|---------------------|------------|-------------------------|------------|----------------------------|------------|-----------------------------------|------------|
|                      | Latitude.           | Longitude. | Latitude.               | Longitude. | Latitude.                  | Longitude. | Latitude.                         | Longitude. |
| Queenborough,        | 0                   | 1          | 0                       | 1          | 0                          | 1          | 0                                 | 1          |
| Sheerness,           | 51 30               | 0 37E      | .                       | .          | .                          | .          | .                                 | .          |
| Orfordness,          | .                   | 0 37E      | .                       | .          | .                          | .          | 51 31                             | 0 30E      |
| Southwold,           | 52 20               | 1 11E      | 52 14                   | 1 36E      | 52 17                      | 1 11E      | .                                 | .          |
| Flamborough Head,    | .                   | .          | .                       | .          | .                          | .          | .                                 | 1 18E      |
| Whitby,              | 54 8                | 0 49W      | 54 9                    | 0 10E      | 54 8                       | 0 11E      | 54 9                              | 0 19E      |
| Hangcliff,           | 54 35               | 1 14W      | 54 28                   | 0 22W      | 54 30                      | 0 50W      | .                                 | 1 55W      |
| Black Point,         | .                   | .          | .                       | .          | .                          | .          | 60 9                              | 0 56W      |
| Hakluyt's Head Land, | 78 32               | 13 10E     | 77 58                   | .          | 78 0                       | 10 50E     | 78 13                             | 10 33E     |
|                      | .                   | .          | .                       | .          | 79 55                      | 12 0E      | 79 47                             | 9 11E      |

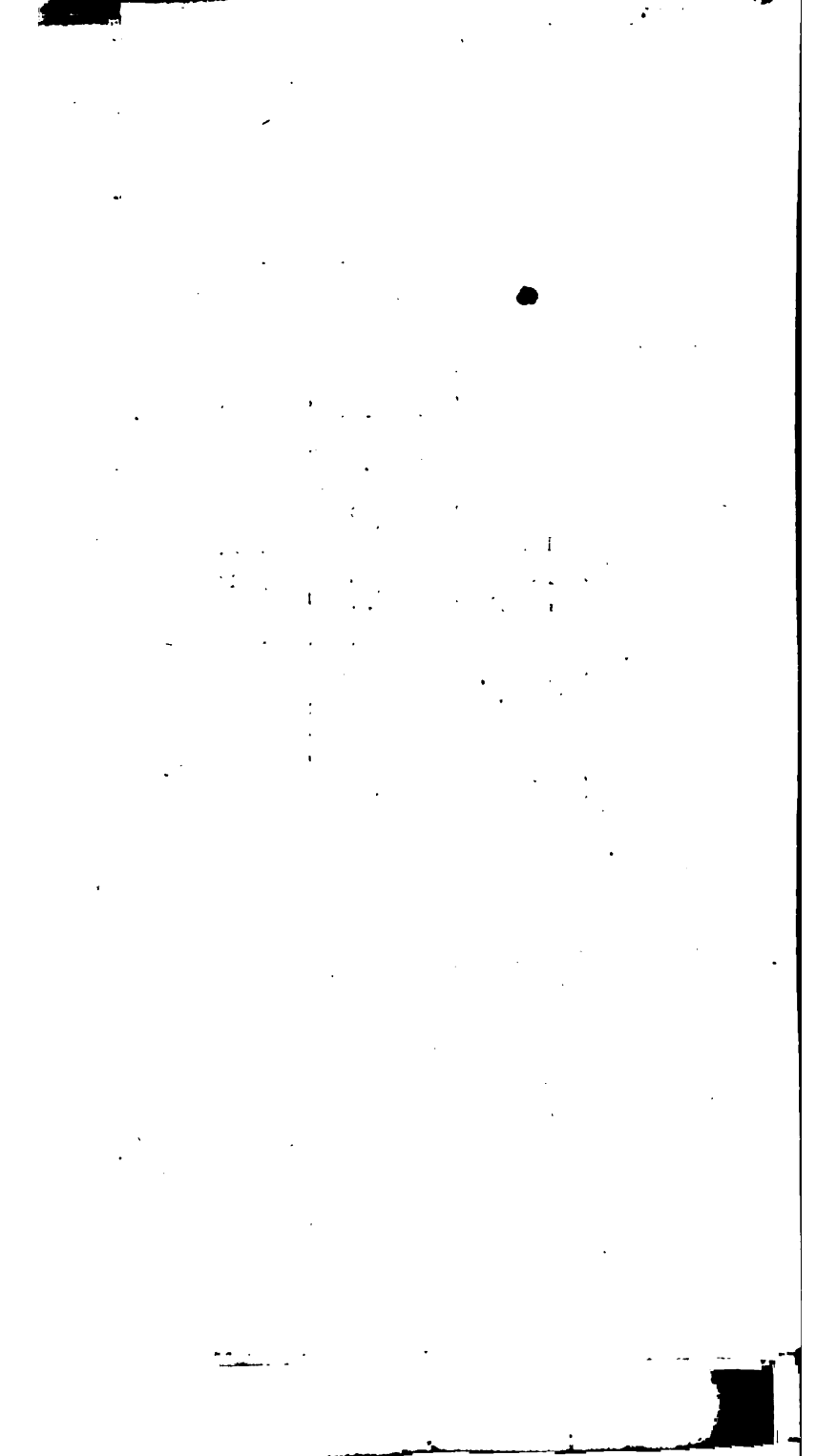




P E I D

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| ar<br>ons. | by the<br>Rekening. |
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| .          | 1 56                |
| .          | 4 58                |
| .          | 6 13                |
| .          | 4 51                |
| .          | 1 46                |
| .          | 0 14                |
| .          | 1 49                |
| .          | 1 28                |
| .          | 0 18                |
| .          | 0 18                |



## OBSERVATIONS ON different METHODS of measuring a SHIP'S WAY.

**T**HE degree of accuracy with which the distance run by a ship can be measured, is a thing of great importance, but unfortunately not easily to be ascertained, from the great variety of circumstances which may occasion errors in the reckoning, and which, though not depending upon the measure of the ship's way, may in voyages not nearly upon a meridian be confounded with those that do. The circumstances of the present voyage gave me the fairest opportunity of trying this experiment, the weather being fine, and the course very nearly upon a meridian; so that an error of one point could not make more than the difference of one mile in fifty in the distance. When the difference of latitude is the same as the distance, it gives frequent opportunities of comparing the reckoning with the observation, and whatever error is found must be attributed to the imperfections in the manner of measuring the distance. Most of the writers on this subject have attributed the errors to a faulty division of the log-line.

Before Norwood measured a degree, the length of a minute had been erroneously supposed 5000 feet; in consequence of which, the log line, from the first use of that instrument about the year 1570, was invariably marked forty-two feet to thirty feet.

conds. Norwood, when he published his *Seaman's Practice*, stated the true measure to be fifty-one feet to thirty seconds; but, as the ship would really run more than is given by the log, and it is right to have the reckoning ahead of the ship, he recommended marking the log line fifty feet to thirty seconds. It does not appear at what time an alteration either in the marking the log, or the length of the glass, took place in consequence of these observations: Sir Jonas Moore in his *Navigation* which was published in the reign of Charles II. mentions, that the seamen, having found the old log not to answer, had shortened the glass to twenty-five seconds, which was equal to a line marked fifty feet with a glass of thirty seconds; but he rather recommends restoring the half minute glass, and making the correction on the line. Since that time the seamen, whether from finding the allowance of one foot in fifty not a sufficient compensation for the accidental errors to which the log is subject, or from a preference of a measure nearly equal to the statute mile, have used a line of forty-five feet to thirty seconds, or a glass of twenty-eight seconds to forty-two feet.

All the writers I have met with, who have treated of the log, except Wilson, have complained of the seamen not having adhered to Norwood's measure. Norwood himself, however, seems to have been aware of the necessity of submitting to the test of experiment the advantages of a new measurement

surement derived from theory. In the preface to his *Seaman's Practice* he says, "Because I am persuaded we have at this day as many excellent navigators in this kingdom, and as great voyages performed, as from any other place in the world, I should be glad to hear of the experimental resolution of this problem by some of them, though it were but running eight or ten degrees near the meridian; for so I doubt not but what I have here written thereof, would receive further confirmation and better entertainment than happily it will now, being so much different from the common opinion."

Had the errors in the distance arisen only from a fault in marking the line, nothing would have been more easy than to have removed that difficulty, by comparing carefully the different measures with the observations, and adhering to that which had been found to correspond best with them. But the distance measured by the log being rendered uncertain by many accidental circumstances, it becomes difficult, or rather impossible, to find any length of line which will shew invariably the distance run by the ship, or even to ascertain with precision that measure which will at all times come nearest the truth. Some of these circumstances are:

1. The effects of currents.
2. The yawning of the ship going with the wind aft, or upon the quarter, when she is seldom



steered within a point each way : this I mention as an error in the distance, and not in the course ; since, though the ship by being yawed equally each way may make the intended course good upon the whole, yet the distance will be shortened as the versed sine of the angle between the line intended and that steered upon.

3. By the ship being driven on by the swell, or the log during the time of heaving being thrown up nearer the ship.

4. By the log *coming home*, or being drawn after the ship, by the friction of the reel and the lightness of the log. Norwood mentions these two last, and says, “ For these causes, it is like, there may “ sometimes be allowed three or four fathoms more “ than is veered out ; but this, (as a thing mutable “ and uncertain) being sometimes more, sometimes “ less, cannot be brought to any certain rule, but “ such allowance may be made as a man in his experience and discretion finds fit.”

5. By the log being only a mean taken every hour, and consequently liable to error from the variations in the force of the wind during the intervals, for which an arbitrary correction is made by the officer of the watch ; and though men of skill and experience come near the truth, yet this allowance must, from its nature, be inaccurate.

These

These circumstances did not escape M. Bouguer's attention, and his ingenuity suggested to him an improvement of the common log, which would correct the errors likely to arise from the most material of these circumstances: a description of this improvement he published at large in the Memoirs of the Academy of Sciences for the year 1747; it has since been abridged in the edition of his Navigation by De la Caille. It appears extraordinary that this log should never have been made use of by others;—the great reputation of the author, as well as the very good reasons he offers in favour of his improvement, were sufficient inducements to me to try the experiment.

In the log which I made use of,

The length of the cone was — 12 inches.

The diameter of the base —  $5\frac{2}{3}$ .

The weight of the cone — — 25 ounces.

The diagonal length of the diver 14 inches.

The length of each side — — 9 $\frac{1}{2}$ .

The weight of the diver — 26  $\frac{1}{2}$  ounces.

The length of line from the diver to the cone, 50 feet; the log line 51 feet to a knot.

Whether M. Bouguer's log will (as he expected) correct the errors arising from currents in the common log, I had no opportunity of discovering in this voyage.

The second error, which no log will correct, cannot be attended with any bad effect, as it must

make the reckoning, in whatever degree it takes place, ahead of the ship.

By observing M. Bouguer's rules in comparing it with the common log, which for that purpose must be reckoned at fifty-one feet, it will, I think, very fully correct the third and fourth, which are the most material errors; as the agitation of the sea from winds does not exceed the depth to which the diver is let down, and the weight of the whole machine prevents the friction of the reel from having an effect in any degree equal to that which it has on the common log.

The fifth arises from the imperfection it has in common with the log generally used.

At first, on the passage out, I contented myself with having Bouguer's log occasionally, to observe what precautions were necessary to be taken to prevent errors, as well as to find whether its variations from the common log were on the same side as the meridian observation required. I found that it was necessary to take care that the diver should be of such a weight as to let only the top of the cone swim; but not heavy enough to sink it, as in that case it would be liable to an error in excess, by measuring the depth that the diver would sink in addition to the ship's way. It was necessary to put a weight of lead to the bottom of the diver, to sink it down to its place before the stray line was out,

The

The line between the diver and the cone should not be more than fifty feet, that being as great a depth as it will sink to whilst the stray line is running off the reel when the ship has much way through the water.

On the passage out, the longest period of my trying this log between two observations, was from the twenty-fifth to the thirtieth; in which time the ship had run four degrees, and the reckoning by Bouguer's log was eighteen miles astern of the ship: but as it appears that the ship on the twenty-sixth, with the wind Northerly, and making barely an East course, was found by the observation to be twenty miles to the Northward of her reckoning, that distance must be attributed to a current; therefore if that current had not taken place, Bouguer's log would have been, instead of eighteen miles astern, two miles ahead of the ship.

On the passage home it was tried from the latitude of eighty degrees eleven minutes to sixty-eight degrees eleven minutes; in which distance, though the ship was much yawed from the sea being frequently upon the quarter, this log was only thirty-one miles ahead of the ship, which might be owing entirely to that circumstance without any other cause.

The state of the common log on the passage out, when the weather was remarkably fine and water in general smooth, was, from the latitude of sixty degrees thirty-seven minutes to seventy-eight degrees eight minutes, with the line marked fifty-

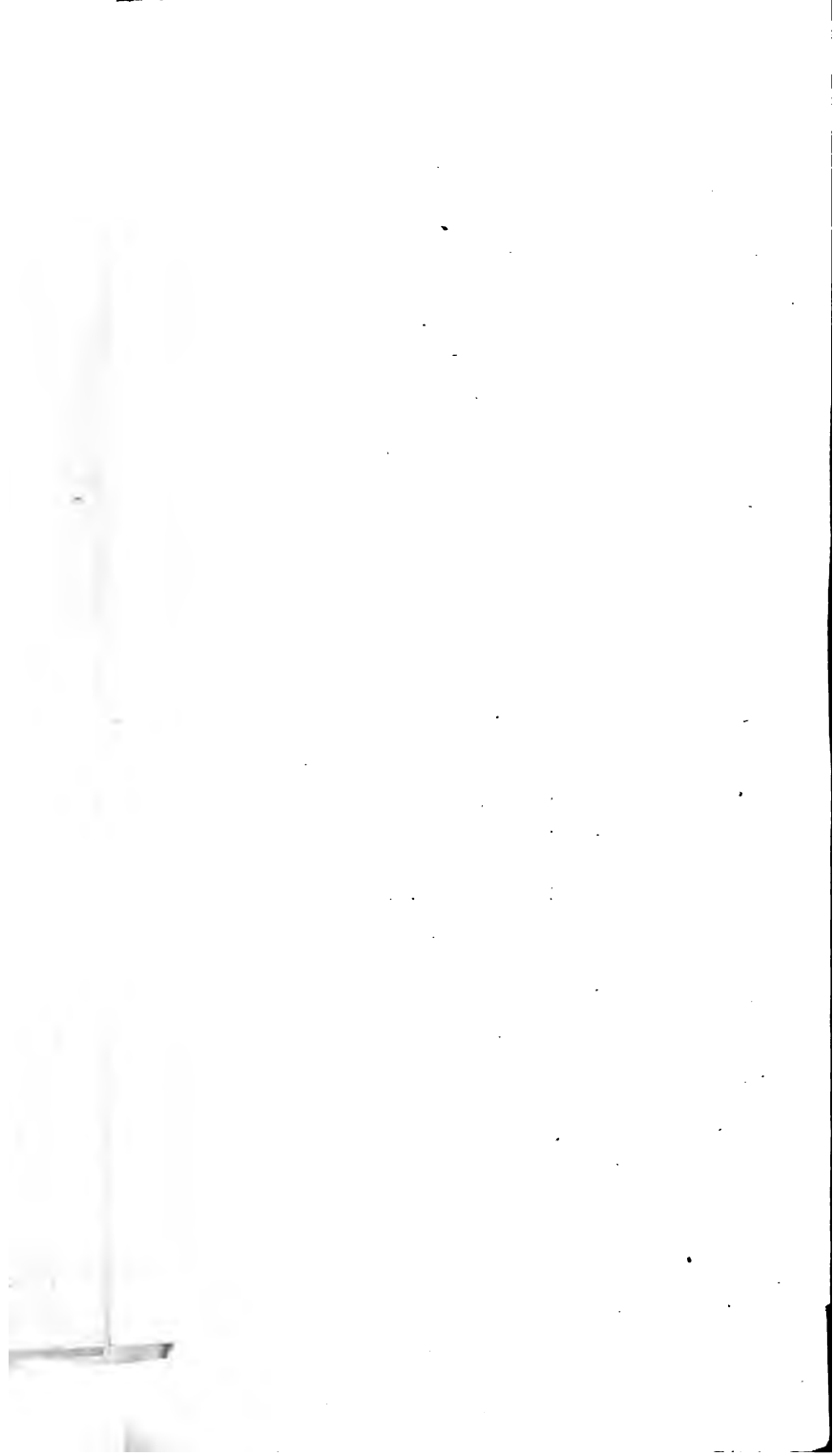
one foot to thirty seconds, one degree fifty-eight minutes astern of the ship, with the line marked forty-five feet to thirty seconds, four miles ahead of the ship. On the passage home, the log at fifty-one feet to thirty seconds, thirty-five miles astern of the ship; at forty-five to thirty seconds, one degree seven minutes ahead of the ship. As far therefore as the experience of this voyage extends, it appears that the errors of the log marked forty-five feet are always on the safe side, and that those of the longer marked line are always short of the run; but that Bouguer's is much more accurate than either.

It is not to be expected that the observations of a single voyage can be sufficient to determine the merit of any instrument, particularly one of so much consequence as the log. I thought it right, however, to give an account of the trial I made of the different methods, and of such remarks as occurred to me.

In the following table the course is put down, in the first column, for all the distances and latitudes; after the distance and latitude, according to each marking of the log, there is a column for the difference between that latitude, and the latitude observed. I thought it best to continue the reckonings without corrections, as if there had been no observation, in order to shew the difference upon the whole run, as well as from one observation to another.

TABLE

|                      |         | By the Co<br>marke |                            |
|----------------------|---------|--------------------|----------------------------|
| Day of the<br>Month. | Courfe. | Distance.          | Latitude<br>by<br>Account. |
|                      | °       |                    | °                          |
| June 16              | N 27 E  | 27                 | 60 3                       |
| 17                   | N 7 E   | 136                | 62 5                       |
| 18                   | N 7 W   | 131                | 65                         |
| 19                   | N 4 W   | 54                 | 65 5                       |
| 20                   | N 20 E  | 59                 | 66 4                       |



I also tried two perpetual logs; one invented by Mr. Russell, the other by Foxon, both constructed upon this principle, that a Spiral, in proceeding its own length in the direction of its axis through a resisting medium, makes one revolution round the axis; if therefore the revolutions of the spiral are registered, the number of times it has gone its own length through the water will be known. In both these the motion of the spiral in the water is communicated to the clock-work within board, by means of a small line, fastened at one end to the spiral, which tows it after the ship, and at the other to a spindle which sets the clock-work in motion. That invented by Mr. Russell has a half spiral of two threads, made of copper, and a small dial with clock-work, to register the number of turns of the spiral. Foxon's has a whole spiral of wood with one thread, and a larger piece of clock-work, with three dials, two of them to mark the distance, and the other divided into knots and fathoms, to shew the rate by the half minute glass, for the convenience of comparing it with the log.

This log, like all others, is liable to the first error, as well as to the second. The third it partakes of in a very small degree, only affecting the reckoning by that quantity which the spiral is thrown towards the ship; whereas in the log the same circumstance affects the whole rate for the hour. The fourth it is entirely free from, as well



as the fifth. It will have the advantage of every other in smooth water and moderate weather, when it is necessary to stand on one course for any particular distance, especially in the night, or a fog, as it measures exactly the distance run. It will also be very useful in finding the trim of a ship, when alone; as well as in surveying a coast in a single ship, or in measuring distances in a boat between headlands or shoals, when a base is not otherwise to be obtained; both which it will do with the greatest accuracy in smooth water, with a large wind, and no tide or current. But notwithstanding these advantages, which will make it very useful and worth having, I doubt much whether it might ever be substituted entirely in the room of the common log. Machines easily repaired or replaced have advantages at sea, which should not lightly be given up for others more specious.

OBSERVATIONS

OBSERVATIONS on the Use of the MEGAMETER  
in Marine Surveying.

THE greatest difficulty in marine surveying is that of obtaining an accurate base, from the extremities of which the angles may be taken with precision, for ascertaining the bearings and distance of headlands and shoals, when either want of time or other circumstances make it impracticable to land and measure a base. The usual way is, to estimate the distance by the log, and to take the angles by the compass. This method is liable to many errors, and affords no means of correcting or discovering them. The Megameter, constructed upon the principles of the object-glass micrometer, described by M. de Charniere and applied by him to find the longitude at sea, I thought might be usefully applied to marine surveying. That which I used was made by Ramsden, with some improvements. The advantages I imagined might be derived from this instrument were, a more correct and expeditious manner of determining the position of coasts, and the distance of shoals or the ship from headlands. This instrument being divided to ten seconds, an angle may be taken by it with great accuracy to five seconds. The height of a ship's mast-head above the water being known, it is easy to find with this instrument, by a single observation; the distance between two ships, and

con-

consequently to determine a base. The angles being taken with an Hadley's quadrant from each of the ships, to the objects whose situations are designed to be ascertained, the distance may be found; and, consequently, their relative situations. If there is a megameter in each ship, the altitudes taken from both ships at one instant, and the angles of the different parts of the coast intended to be surveyed observed with an Hadley's quadrant at the same time, will give the situation with more accuracy and expedition than any method of surveying from ships hitherto practised; with the farther advantage of the certain means of detecting any error in the observation, so as to judge whether it is of sufficient importance to be attended to. The only precautions necessary are; to make the observations at the same instant, to prevent their being affected by any alteration in the relative position of the ships, as a very small one there would occasion a considerable error in the distance; and to be careful in chusing objects sufficiently defined and remarkable. This method of surveying has the further advantage of giving the scale of a coast; Seamen, though they judge very accurately of their distance from places upon coasts well known to them, are very often mistaken when they fall in with land they have never seen before; of which we had, at first, some instances in this voyage, the height of the mountains, before we knew the scale of the coast, making us always think ourselves nearer

nearer the land than we really were. Where the coast is at all high, the megameter affords a very accurate and expeditious method of determining the height of all the points, when their distances are found; and thence, the heights being known, of ascertaining immediately by a single observation the situation of the ship, or the latitude of any point by the bearings at the time of a meridian observation; the direction and rate of currents or tides may also be found in this manner with great accuracy. I made several observations during this voyage with the megameter, some of which I shall give as examples; they were sufficient to prove to me the great accuracy that may be attained with this instrument after some practice. The utility of such a method of obtaining a survey on an enemy's or undescribed coast, as well as that of being able to prove the truth of charts by a single observation, is obvious.

June the fifteenth, the ship being in latitude  $60^{\circ} 19'$ , longitude  $0^{\circ} 39' W$ , Hangcliff bore  $S 63^{\circ} 00' W$ ; variation,  $23^{\circ} W$ .

The altitude of the Carcass's mast, by the megameter, was  $35^{\circ} 48''$ ; height of the mast, 102.75 feet; hence the distance between the Racehorse and Carcass was 9861 feet: angle between the Carcass and Hangcliff,  $85^{\circ} 48'$ ; between the Racehorse and Hangcliff,  $87^{\circ} 00'$ ; From whence the difference of latitude was found  $10' S$ ; difference  
of

of longitude  $17'$  W. Therefore, the latitude of Hangcliff is  $60^{\circ} 9'$ ; longitude  $0^{\circ} 56'$  W.

July the second, to try how far the megameter could be depended upon, I observed the altitude of the Carcas's mast  $2^{\circ} 23' 48''$ ; the angle between the main-yard and main-topfail yard,  $0^{\circ} 44' 26''$ ; hence the distance between the main-yard and main-topfail yard came out — 31,750 feet.  
By measurement it was found 34,125 feet.

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Difference 2,375 feet.

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The distance between the two ships, deduced from the altitude of the mast, was 2457 feet.  
By the angle of the main and main-topfail yard, the distance between them being .  
34,125 feet, — — 2640 feet.

---

Difference 183 feet.

---

Which is not more than the ships might have changed their position in the time of reading off and setting down the first observation before taking the second.

An error of ten seconds in the observation of the angle subtended by the mast at this distance, would make an error of two feet and three quarters in the distance. At the distance of a nautical mile it would produce an error of sixteen feet. At other distances the error decreases as the squares of the distances

distances decrease; and at other heights it decreases as the heights decrease.

Whenever the distance of the object, whose angle is taken by the megameter, does not exceed that of the visible horizon, the very small portion of the earth's surface intercepted between the object and observer, may be considered as a plane, to which the object is perpendicular, and the distance may be concluded by resolving the right-angled triangle, formed by the upright object, and lines drawn from the observer's station to the top and bottom of it.

But in greater distances, the bottom of the object being concealed from the sight of the observer, it becomes necessary to have recourse to a different calculation.

The only cases which can occur in practice are two; the one when the height is given to find the distance; the other when, the distance being known, the height of the object is to be deduced from the observation: both which are easily solved by the following practical rules.

#### To find the Distance.

To the apparent altitude of the object above the sensible horizon, add the complement of the dip answering to the height of the observer's eye above the sea; the sum is the angle B A E (fig. 1.); and say: As the semi-diameter of the earth increased by the height of the object, is to the semidiameter increased by the height of the eye; so is the sine of  
B A E,

# 104 A P P E N D I X.

BAE, to another line, which is that of the angle B; the difference between  $180^\circ$ , and the sum of the two angles BAE and B, is the value, in degrees and minutes, of the arc GC of the earth's surface intercepted between the eye and object. Multiply the number of minutes and decimal parts of a minute in this arc by the value of one minute in miles, fathoms, or such measure as may be most convenient, and you will have the distance in the like measure.

## E X A M P L E.

The height of Snow Peak being 1503 yards, its apparent altitude above the horizon of the sea was observed to be — —  $1^\circ 47' 6''$

The height of the eye being 16 feet,  
the complement of the dip is  $82^\circ 56' 11''$

The sum is E A B  $91^\circ 43' 17''$

To the semidiameter of the earth

|  |                |                                     |   |  |
|--|----------------|-------------------------------------|---|--|
| in yards                               | 6966382        | -                                   | - | 6966382                                |
| Add the height<br>of the object        | 1503           | Add the height<br>of the eye        |   | $5\frac{1}{2}$                         |
| Semidiam. +<br>height of the<br>object | <u>6667885</u> | Semidiam. +<br>height of<br>the eye |   | <u><math>6966387\frac{1}{2}</math></u> |

As

# A P P E N D I X. 105

|                              |                |                   |
|------------------------------|----------------|-------------------|
| As 6967885                   | Co. Ar.        | 3,1568990         |
| To 6966387 $\frac{1}{2}$     |                | 6,8430076         |
| So is Sine E A B 90° 43' 17" |                | <u>9,9998040</u>  |
| To sine B                    | 87 54 30       | <u>19,9997106</u> |
|                              | 179 37 47      |                   |
| Subtracted from              | 180 0 0        |                   |
|                              | <u>0 22 13</u> | the distance.     |

Therefore the distance is 22,22 minutes, or nautical miles.

This multiplied by - 2040 the number of yards  
in one minute,  
The product 45328,8 is the distance in  
yards.

## To find the Height.

To the apparent altitude of the object above the sensible horizon, add the complement of the dip answering to the height of the observer's eye above the sea, the sum is the angle B A E; to this add the horizontal distance of the eye and object in degrees and minutes, and subtract the sum from 180°, the remainder is the angle B: then say, as the sine of B is to the sine of B A E, so is the semidiameter of the earth increased by the height of the eye to a fourth number; from which subtracting the semidiameter of the earth, the remainder is the height of the object.

L

EXAMPLE



## E X A M P L E.

July the second, the apparent altitude of Snow Peak was observed to be, at the distance of 37507 yards or 18' 30"

2° 12' 20"

The height of the eye being 5  $\frac{1}{2}$  yards, the complement of the dip is      -      -      -      -

89    56    11

Hence the angle B A E    92    8    31

Horizontal distance                    18    30

92    27    1

Subtracted from    180

Angle B    87    32    59

Semidiameter of the earth 6966382

Height of the Eye                    5  $\frac{1}{2}$

Semidiameter + height of

the eye                    6966387  $\frac{1}{2}$

As sine B    87° 32' 59" Co. Ar. 0,0003972

To sine B A E 92    8    31                    9,9996965

So is semidiameter + height

of the eye = 6966387  $\frac{1}{2}$  yards    6,8430076

To 6967888                    6,8431013

Semidiameter 6966382

Height                    1506 in yards.

DEMON-

## D E M O N S T R A T I O N.

Let  $GFC$  (plate I. fig. 1.) represent the surface of the earth,  $E$  its centre,  $BC$  the height of a hill or other object rising perpendicular from  $C$ ;  $A$  is the place of the observer's eye, whose height above the level of the sea is  $AG$ . Draw  $AH$  perpendicular to  $AE$ , and  $AF$  touching the circle  $GFC$  in  $F$ . Then  $HAF$  is the dip,  $EAF$  its complement,  $DAB$  is the apparent altitude of the object above the sensible horizon; to this add  $EAD$ , the sum is  $EAB$ . In the triangle  $EAB$ , the side  $EA$  is the sum of the semidiameter  $EG$  and  $GA$  the height of the observer's eye;  $EB$  the sum of the semidiameter  $EC$  and  $CB$  the height of the object; the angle  $AEB$  is measured by  $GC$  the horizontal distance between the observer and object. Now in the first case there are given in the triangle  $EAB$ , the sides  $EA$ ,  $EB$ , and the angle  $BAE$ , to find the angle  $AEB$ ; and in the second there are given the angles  $BAE$ ,  $AEB$  and the side  $EA$ , to find the side  $EB$  and consequently  $BC$ . The trigonometrical solutions of these cases are the above practical rules.

## OBSERVATIONS on the VARIATION.

THE Variation of the compass, always an interesting object to navigators and philosophers, became peculiarly so in this voyage from the near approach to the Pole. Many of the theories that had been proposed on this subject, were to be brought to the test of observations made in high latitudes, by which alone their fallacy or utility could be discovered. They of course engaged much of my attention, and gave me the fullest opportunity of experiencing, with regret, the many imperfections of what is called the Azimuth compass. This instrument, though sufficiently accurate to enable us to observe the variations so as to steer the ship without any material error, with the precaution of always using the same compass by which they are taken, is far from being of such a construction as to give the variation with that degree of precision, which should attend experiments on which a theory is to be founded, or by which it is to be tried. The observations taken in this voyage will fully evince this, by their great variations from one another in very short intervals of time; nor is this disagreement of successive observations peculiar to the higher latitudes, and to be imputed to a near approach to the Pole, as I found it to take place even upon the English coast.

As to the observations themselves, they were taken with the greatest care, and the most scrupulous attention to remove every circumstance which

which might be supposed to create an accidental error; the observations being taken sometimes by different people with the same compass, in the same and different places; sometimes with different compasses, changing the places and the observers repeatedly, to try whether there was any error to be imputed to local attraction, or the different mode of observation by different persons. I have since my return tried the compasses by a meridian as well as by taking azimuths, and find them to agree with one another, though the same compass sometimes differs from itself a degree in successive observations.

That every person may (as far as is possible without having been present at the time) be enabled to judge of the degree of accuracy to be expected in such observations, as well as the degree of attention paid to those made by us, I have set down every circumstance that I thought material, giving every part of each observation, with each separate result, and the mean of every set, with the weather at the time. Whenever I mention its blowing fresh, it was only comparatively with respect to the rest of the voyage, no observation having been made in any weather which might not generally speaking be called fine.

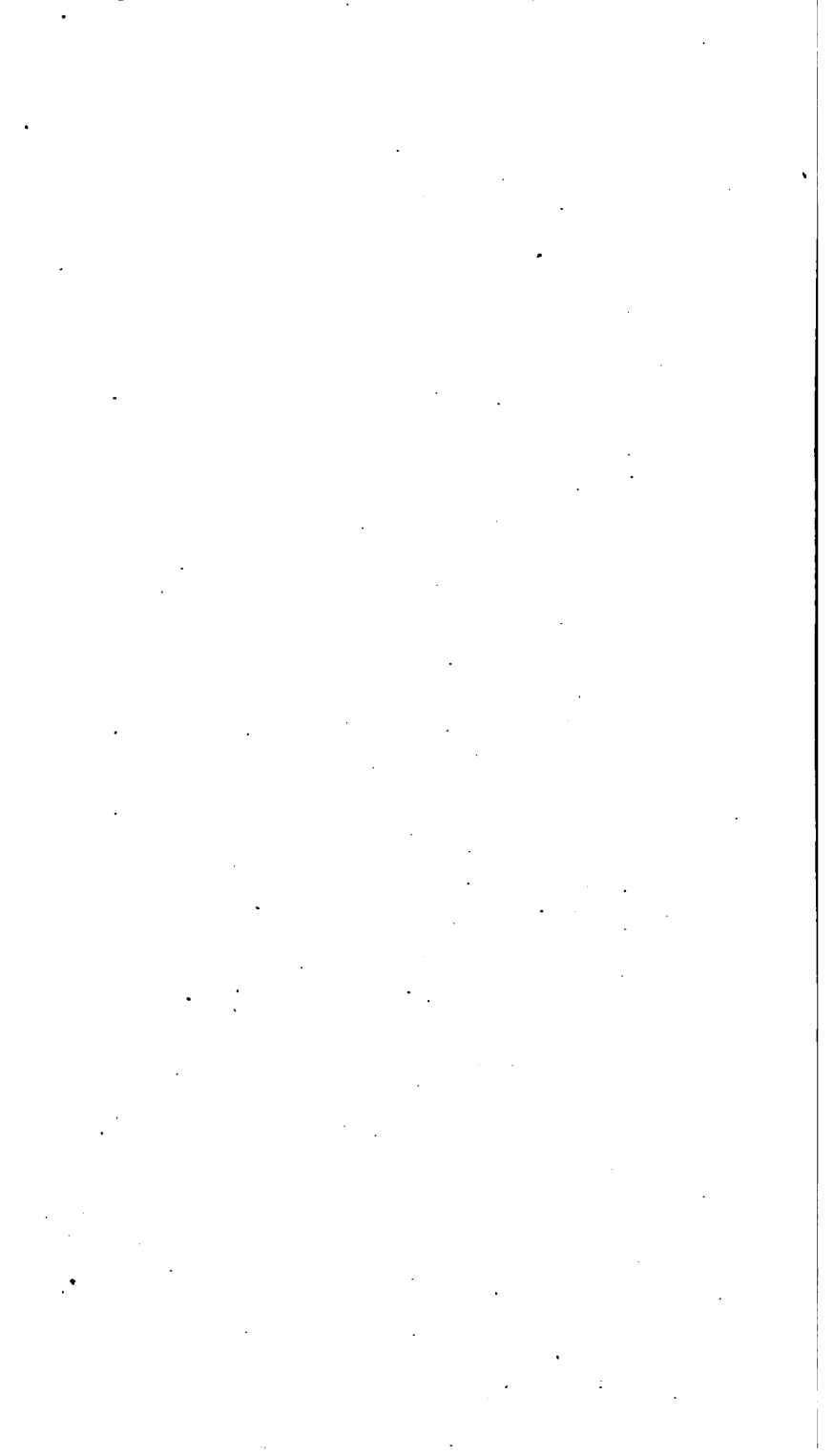
Having said so much of the inaccuracy of the instrument, I must add, that I think some general and rather curious inferences may safely be drawn from these observations. One is, that the variation

near the latitude of eighty, if it alters at all with time, does not alter in any degree as it does in these latitudes: the variation having been found by Poole in 1610 to be  $22^{\circ} 30'$  W in latitude  $78^{\circ} 37'$ ;  $18^{\circ} 16'$  W in Cross Road in latitude  $79^{\circ} 15'$  N; and  $17^{\circ} 00'$  within the foreland in latitude  $78^{\circ} 24'$ . By Baffin in 1613, in Horne Sound, latitude  $76^{\circ} 55''$ , the variation from the meridian was  $12^{\circ} 14'$  W; but by his compass  $17^{\circ}$ : his compass "was touched  $5\frac{1}{2}$  Easterly," that being the variation in London at that time: in Green Harbour, latitude  $77^{\circ} 40'$ , he observed the variation  $13^{\circ} 11'$  W. Fotherby in 1614, made the variation in Magdalena Bay, latitude  $79^{\circ} 34'$  N,  $25^{\circ} 00'$  W; and in latitude  $79^{\circ} 8'$ , two points. Neither Poole nor Fotherby mention whether their variations are reckoned from the meridian, or whether their compasses, like Baffin's, were fitted to the variation at that time in London. If Fotherby's were taken with a compass in which a correction was made for the variation at London, his observation agrees exactly with those made by me in Vogel Sang and Smeerenberg; and those of Poole and Baffin differ so little from mine, that the difference need not be regarded. But the variation in London now differs from what it was at that time above twenty-six degrees.

The other inference is, that in going to the Eastward in the latitude of eighty, the Westerly variation decreases very considerably from a difference in the longitude.

Table

|                           |       |       |      |          |        |                 |   |       |  |
|---------------------------|-------|-------|------|----------|--------|-----------------|---|-------|--|
| <sup>28</sup><br>at 6 AM. | 80 30 | 15 14 |      |          |        |                 | 12 54<br>11 24<br>11 24<br>11 56<br>12 30 | 11 56 | Light Breezes, and the Water smooth.             |
| <sup>31</sup><br>at 4 PM. | 80 35 | 19 0  |      |          |        |                 | 12 24                                     |       | The Weather very fine, and the Water quite fill. |
|                           | 79 44 | 9 51  |      |          |        | At Smeerenberg. | 18 57                                     |       |  |
| Aug. 31.<br>at 4 PM.      | 68 46 | 3 24  | 15 3 | N 87 59W | 107 32 |                 | 19 33                                     |       |  |
|                           |       |       | 4 25 | N 52 12W | 70 10  |                 | 25 4                                      |       |  |



ACCOUNT of the OBSERVATIONS made with the  
MARINE DIPPING NEEDLE, constructed for  
the Board of Longitude by Mr. Nairne.

THE instrument, hanging by an universal joint on a triangular stand, is adjusted so as to hang in a plane perpendicular to the horizon, by means of a plumb line, which is to be suspended on a pin above the divided circle, and the dovetail work, which alters the position of the instrument, by turning a button. The two 90° on the divided circle, are adjusted so as to be perpendicular to the horizon, by the same plumb line and the adjusting screw: and at the lowest 90°, when it is adjusted, the pointer is fixed. The length of the magnetic needle is twelve inches, and its axis (the ends of which were of gold alloyed with copper) rested on friction wheels of four inches diameter, each end on two friction wheels; which wheels were balanced with great care. The ends of the *axes* of the friction wheels were likewise of gold alloyed with copper, and moved in small holes made in bell metal; and opposite the ends of the *axes* of the needle and the friction wheels, were flat agates finely polished. The magnetic needle vibrated within a circle of bell metal, divided from the lower 90° each way, as far as sixty-five degrees, into degrees and half-degrees: the



“ other divisions were two degrees and a half; the  
 “ needle being very nearly balanced before it was  
 “ made magnetical: but by means of the cross,  
 “ fixed on the axis of the needle (on the arms of  
 “ which were cut very fine screws, to receive the  
 “ small buttons, that might be screwed nearer or  
 “ farther from the axis) the needle could be ad-  
 “ justed both ways to a great nicety, after it was  
 “ made magnetical, by changing the sides of the  
 “ needle, and reversing the Poles. As this needle  
 “ at sea could seldom remain at rest; to remedy  
 “ in a great measure this inconvenience, the di-  
 “ vided circle is made moveable by turning the  
 “ button; so that when it is used at sea, the di-  
 “ vided circle is moved till some principal division  
 “ is the mean of the vibrations: then that number  
 “ of degrees and half-degrees distant from the  
 “ pointer, subtracted from ninety, gives the dip,  
 “ if the needle is properly balanced: but lest it  
 “ should be somewhat out of balance, the most  
 “ certain way is, first, to take the dip with the  
 “ face of the divided circle to the East, and after-  
 “ wards to the West, and then changing the ends  
 “ of the needle by reversing the Poles, and taking  
 “ the dip as before, with the divided circle front-  
 “ ing the East and West: and the mean of those  
 “ four dips will be the most accurate. In each case,  
 “ when the dip is taken, the instrument must be  
 “ so placed that the needle vibrates in the magnetic  
 “ meridian.”

The

The observations on the dip of the needle, during this voyage, were made with great care: first the dip was observed with the divided arch to the East, the instrument being placed as near as possible in the magnetic meridian; it was then turned, and the observation made with the divided arch to the West: the poles being changed, the observation was repeated in the same manner. The actual observations are expressed in the second, third, fourth, and fifth columns; and the mean result in the sixth. It appears by these observations that the dip increases in going North.

There is no reason at present to suppose that the dip is liable to any variation in the same place at different periods of time, it having been observed in London by Norman, who first discovered it in 1592, to be  $71^{\circ} 50'$ ; and by Mr. Nairne, in 1772, about  $72^{\circ}$ . The difference between these observations, taken at such distant periods, is smaller than that found between several of Mr. Nairne's observations compared with each other; and therefore we have no reason to conclude that the dip has altered since Norman's time: the care with which his instrument was constructed, and his observations made, leaves no room to doubt of their accuracy.

TABLE of the OBSERVATIONS made with the  
Marine DIPPING-NEEDLE.

| Day of the Month. | West. | East. | West. | East. | Mean Dip | Place of Observation. |  |
|-------------------|-------|-------|-------|-------|----------|-----------------------|--|
|                   | ° /   | ° /   | ° /   | ° /   | ° /      |                       |  |
| June 2 P. M.      | 73    | 073   | 15    | 73    | 20       | 74 30                 | } Latitude 51 35<br>near the Buoy<br>of the Upper<br>Middle. |
| 2 P. M.           | 74    | 30    | 73    | 073   | 20       | 73 30                 |  |
| 5 P. M.           | 70    | 20    | 73    | 073   | 15       | 72 15                 | } Off Harwich<br>In Southwold<br>Bay.                        |
| 6 P. M.           | 72    | 075   | 072   | 074   | 30       | 73 22                 |  |
| 14 P. M.          | 72    | 30    | 73    | 30    | 74       | 074                   | } Off Shetland   |
| 8 P. M.           | 75    | 15    | 75    | 30    | 74       | 076 30                |  |
| 15, 8 A. M.       | 74    | 30    | 74    | 30    | 75       | 075 30                | } Latitude 60 18   |
| P. M.             | 74    | 30    | 75    | 30    | 75       | 075 0                 |  |
| 16 P. M.          | 77    | 076   | 30    | 76    | 30       | 77 076                | } Latitude 70 45   |
| 22 Noon           | 78    | 077   | 30    | 78    | 078      | 077 52                |  |
| 23, 9 P. M.       | 81    | 30    | 80    | 083   | 081      | 30                    | } Latitude 72 40   |
| 24 Noon           | 82    | 30    | 79    | 30    | 81       | 30                    |  |
| P. M.             | 77    | 30    | 77    | 30    | 81       | 082 079               | } Latitude 73 22   |
| 26, 2 P. M.       | 77    | 30    | 80    | 082   | 078      | 079 22                |  |
| 28 Mid.           | 83    | 30    | 80    | 082   | 079      | 081 7                 | } Latitude 73 36   |
| 29, 2 P. M.       | 79    | 15    | 81    | 078   | 30       | 83 080                |  |
| 30 Noon           | 76    | 45    | 79    | 30    | 82       | 30                    | } Latitude 74 30   |
| July 2, Mid.      | 80    | 30    | 82    | 30    | 80       | 30                    |  |
| 9, 6 P. M.        | 82    | 45    | 81    | 45    | 83       | 080 081               | } Latitude 77 48   |
| 15                | 81    | 45    | 81    | 15    | 82       | 082 30                |  |
| 29 Mid.           | 83    | 15    | 83    | 080   | 40       | 81 15                 | } On Shore.<br>Latitude 79 50                                |
| August 14         | 83    | 083   | 081   | 15    | 81       | 20                    |  |
| 31 P. M.          | 79    | 30    | 77    | 45    | 80       | 079 079               | } Latitude 80 27   |
|                   |       |       |       |       |          |                       |  |
|                   |       |       |       |       |          |                       | } At Smeeren-<br>berg. Latitude<br>79° 44' on<br>shore.      |
|                   |       |       |       |       |          |                       |  |
|                   |       |       |       |       |          |                       | } Latitude 69° 2'  |
|                   |       |       |       |       |          |                       |  |

ACCOUNT of the INSTRUMENTS made use of for  
keeping the METEOROLOGICAL JOURNAL.

**T**HE Marine Barometer was made by Mr. Nairne, from whom I received the following description :

“ The bore of the upper part of the glass tube  
“ of this barometer, is about three-tenths of an  
“ inch in diameter, and four inches long. To  
“ this is joined a glass tube, with a bore about  
“ one-twentieth of an inch in diameter. The two  
“ glass tubes being joined together, form the tube  
“ of this barometer ; and being filled with mer-  
“ cury, and inverted into a cistern of the same, the  
“ mercury falls down in the tube till it is counter-  
“ balanced by the atmosphere. .

“ In a common barometer, the motion of the  
“ mercury up and down in the tube is so great at  
“ sea, that it is not possible to measure its perpen-  
“ dicular height; consequently, cannot shew any  
“ alteration in the weight of the atmosphere: but  
“ in this marine barometer, that defect is reme-  
“ died. The instrument is fixed in gimbals, and  
“ kept in a perpendicular position by a weight  
“ fastened to the bottom of it.

“ The

“ The perpendicular rising or falling of the mercury is measured by divisions, on a plate divided into inches and tenths, and by a Vernier division into hundredths of an inch, which is fixed to the side of the tube.”

The **HYGROMETER** I was favoured with by M. De Luc; and the following account is a literal translation of that which he gave me in French.

THE part of M. De Luc's Hygrometer which is affected by the impressions of the moisture of the air, is a hollow cylinder of ivory, two inches eight lines long, and internally two lines and a half in diameter. It is open only at one end; and the thickness of its sides, for the length of two inches six lines from the bottom, is but three-sixteenths of a line. It is this thin part which does the office of an hygrometer; the remaining part of the cylinder, towards its orifice, must be kept a little thicker, being destined for joining it to a tube of glass, thirteen or fourteen inches long. This junction is effected by means of a piece of brass, and the whole is cemented together with gum lac.

M. De Luc's reason for chusing ivory as the hygrometer, is, that this matter appeared to him more proper than any other for receiving the impressions of the moisture of the air, without suffering thereby any essential change. The cylinder made of it becomes more capacious, in proportion  
as

as it grows moister. This is the fundamental principle of the instrument. M. De Luc has since found, that upon letting this cylinder lie some time in water of an uniform temperature, it swells to a certain point, after which it dilates no farther. This circumstance furnished him with a *maximum* of humidity; and, consequently, with one point of comparison in the scale of the hygrometer; and this point he has fixed at the temperature of melting ice. For measuring the differences in the capacity of this ivory cylinder, and thereby discovering its different degrees of moisture, M. De Luc makes use of quicksilver, with which he fills the cylinder, and a part of the communicating glass tube. The more capacious this cylinder is, or, which is the same, the moister it is, the lower does the mercury stand in the glass tube; and *vice versa*. Now M. De Luc has found, that the lowest point to which it can sink, is that where it stands when the ivory cylinder is soaked in melting ice: he therefore names this point *zero*, in the scale of his hygrometer; and consequently, the degrees of this scale are *degrees of dryness*, counted from below upwards, as the quicksilver rises in the glass tube.

To give these degrees a determinate length, and thus render the hygrometers capable of being compared with each other, M. De Luc employs in constructing them such glass tubes as have been previously prepared, by being made into thermometers,

and

and filled with mercury, so as to ascertain upon them the points of melting ice and boiling water, and to take exactly the distance between those points by any scale at pleasure. That done, the bulb of this preparatory thermometer must be broken, and the quicksilver it contains exactly weighed. It is by knowing the weight of this, together with the distance between the fixed points of the thermometer, that the scale of the hygrometer is determined. For instance, let the weight of the quicksilver be one ounce, and the distance between the two abovementioned points, one thousand parts of a certain scale: then suppose that the quicksilver in the hygrometer, to which this tube is to be applied, weighs only half an ounce; this will give a fundamental line, consisting of five hundred parts of the same scale. The fundamental line, thus found, is applied to the scale of the hygrometer, beginning at *zero*, and measuring it off about four times over, that the whole variation of the instrument may be comprehended. Each of those spaces being afterwards divided into forty equal parts, gives such degrees as M. de Luc has found most convenient. In general terms, the length of the fundamental line of the hygrometer, must be to the interval between the two fixed points of the preparatory thermometer, as the weight of the quicksilver in the hygrometer, is to the weight of the quicksilver in that thermometer.

This

This proportion between the scale of the hygrometer and that of the preparatory thermometer, furnishes an easy method of correcting in this instrument the effects of heat upon the mercury it contains.

It will easily be conceived, from the construction of the scale of this hygrometer, that if its cylinder of ivory was suddenly changed into glass, the instrument would become a true thermometer, in which the interval between the points, answering to melting ice and boiling water, would be divided into forty parts. If, therefore, a thermometer, with a scale similarly divided into forty parts between the fixed points, be placed near the hygrometer, it will shew immediately the correction to be made on that instrument for its variation as a thermometer; with some restrictions, however; of which M. De Luc has given an account in the paper he sent to the Royal Society on the subject of this hygrometer.

That part of the frame of the instrument on which the scale is marked, is moveable; so that, before observing the points at which the mercury stands, it may be pushed upwards or downwards, according as the thermometer has risen or fallen with respect to the point of melting ice: and thus the indications of the hygrometer can at once be freed from the errors which would arise from the difference in the volume of the quicksilver, on account of the different degrees of heat.

Description



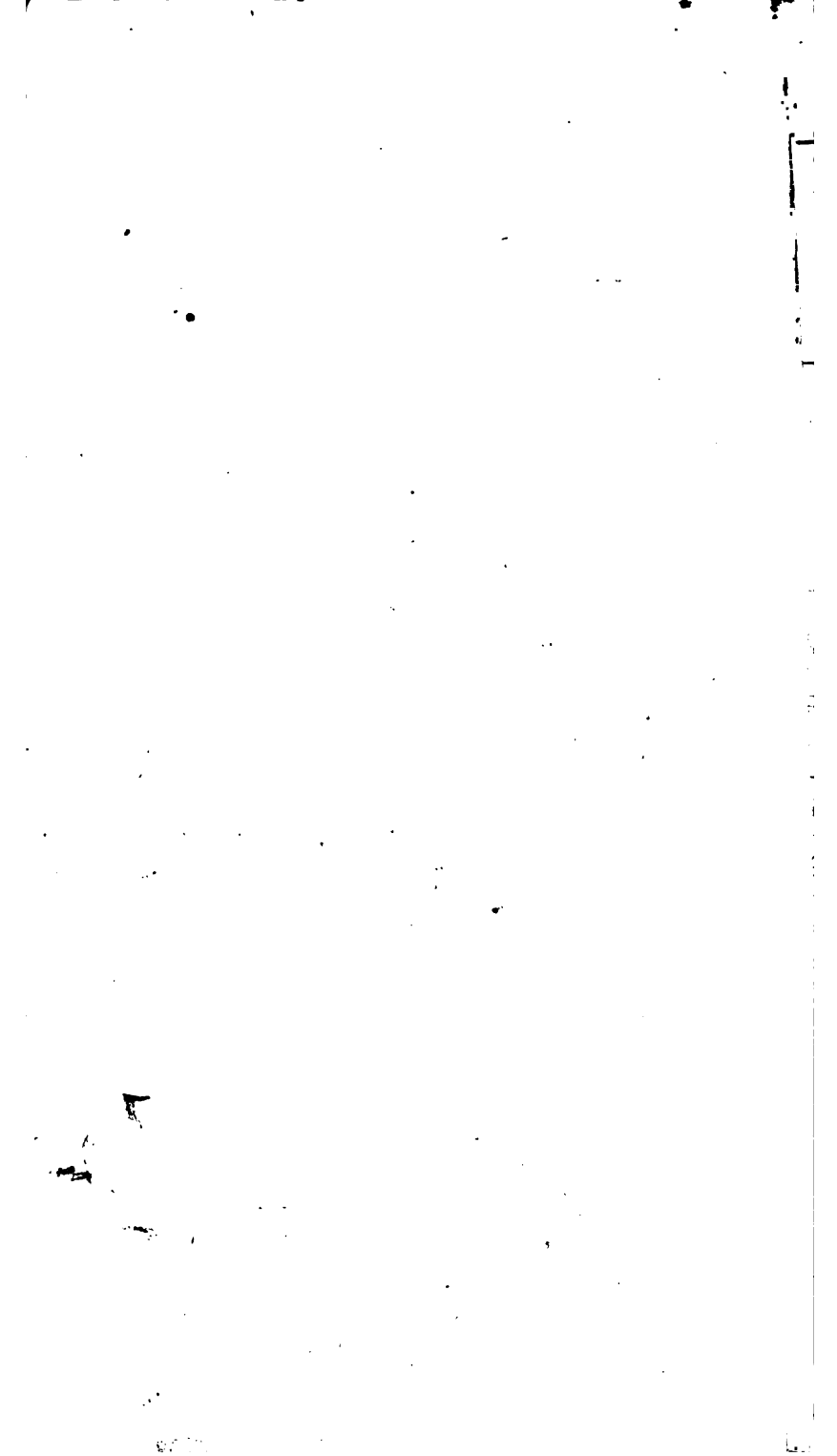
Description of the Manometer, constructed by  
Mr. Ramsden.

THE Manometer used in this voyage was composed of a tube of a small bore, with a ball at the end; the barometer being at 29.7, a small quantity of quicksilver was put into the tube to take off the communication between the external air, and that confined in the ball and the part of the tube below this quicksilver. A scale is placed on the side of the tube, which marks the degrees of dilatation arising from the increase of heat in this state of the weight of the air, and has the same graduation as that of Fahrenheit's thermometer, the point of freezing being marked 32. In this state therefore it will shew the degrees of heat in the same manner as a thermometer. But if the air becomes lighter, the bubble inclosed in the ball, being less compressed, will dilate itself, and take up a space as much larger, as the compressing force is less; therefore the changes arising from the increase of heat will be proportionably larger; and the instrument will shew the differences in the density of the air, arising from the changes in its weight and heat. Mr. Ramsden found, that a heat, equal to that of boiling water, increased the magnitude of the air from what it was at the freezing point  $\frac{1}{1000}$  of the whole. From this it follows, that the ball and the part of the tube below the  
beginning

beginning of the scale is of a magnitude equal to almost 414 degrees of the scale.

If we have the height of both the manometer and thermometer, the height of the barometer may be thence deduced by this rule; as the height of the manometer increased by 414, is to the height of the thermometer increased by 414; so is 29,7, to the height of the barometer.

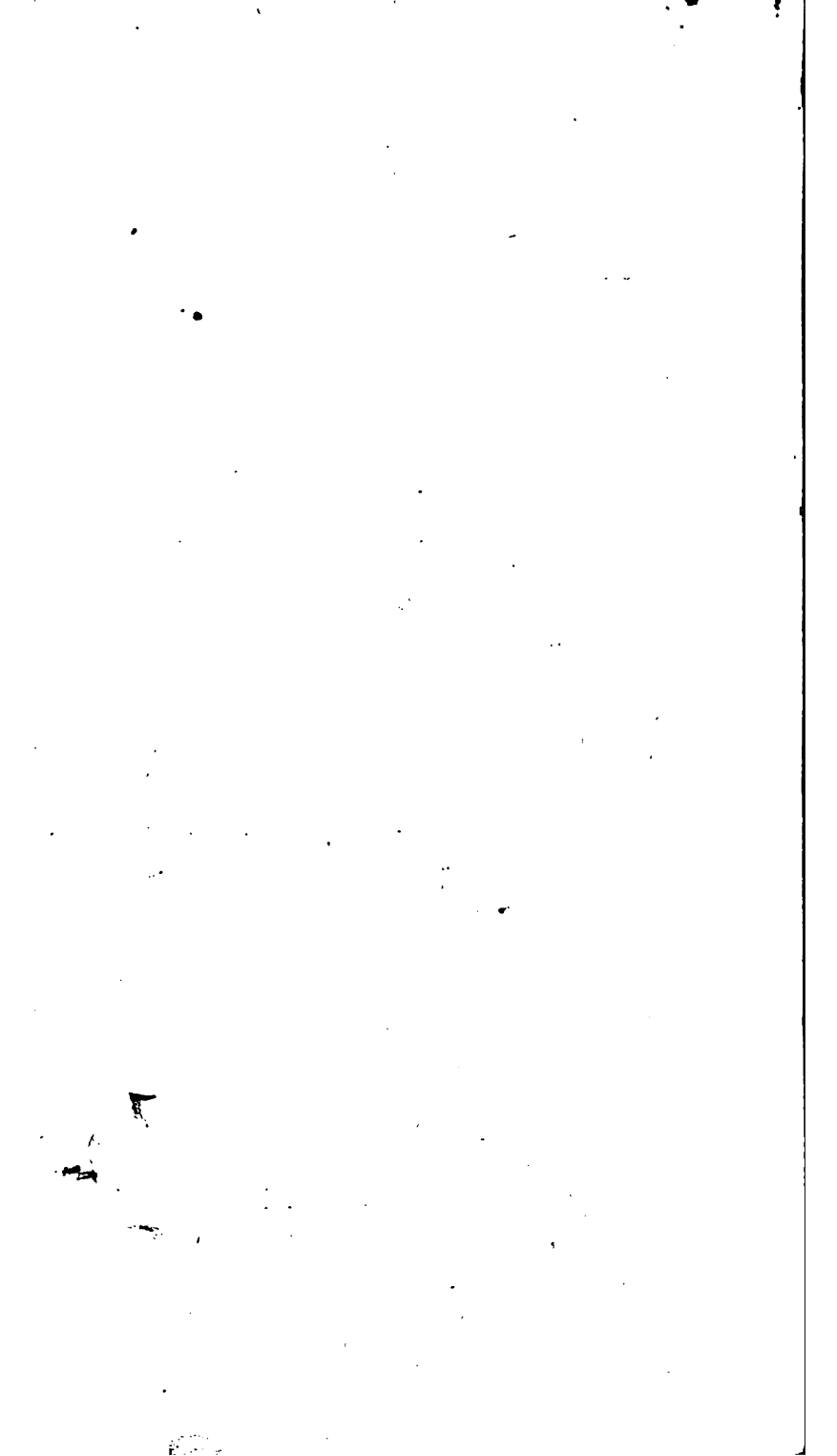
This instrument, though far from complete, having been constructed in a hurry for the purpose of a first experiment, and liable to some inaccuracies in the observations from not having the thermometer with which it was compared attached to it, seldom differed from the marine barometer  $\frac{1}{8}$  of an inch. Should it be improved to that degree of accuracy of which it seems capable, it will be of great use in determining refractions for astronomical observations, as well as indicating an approaching gale of wind at sea.



|  |    |           |                  |       |    |    |    |    |   |    |            |
|--|----|-----------|------------------|-------|----|----|----|----|---|----|------------|
|  | 2. | Noon.     | 50               | 29.85 | 63 | 47 | 79 | 57 | 0 | 37 | 65, cloudy |
|  |    | Midnight. | 41 $\frac{1}{2}$ |       |    |    |    |    |   |    |            |
|  |    | Noon.     | 39 $\frac{1}{2}$ | 29.86 | .  | .  | .  | .  | . | .  |            |
|  |    | 6 P. M.   | 41               |       |    |    |    |    |   |    |            |

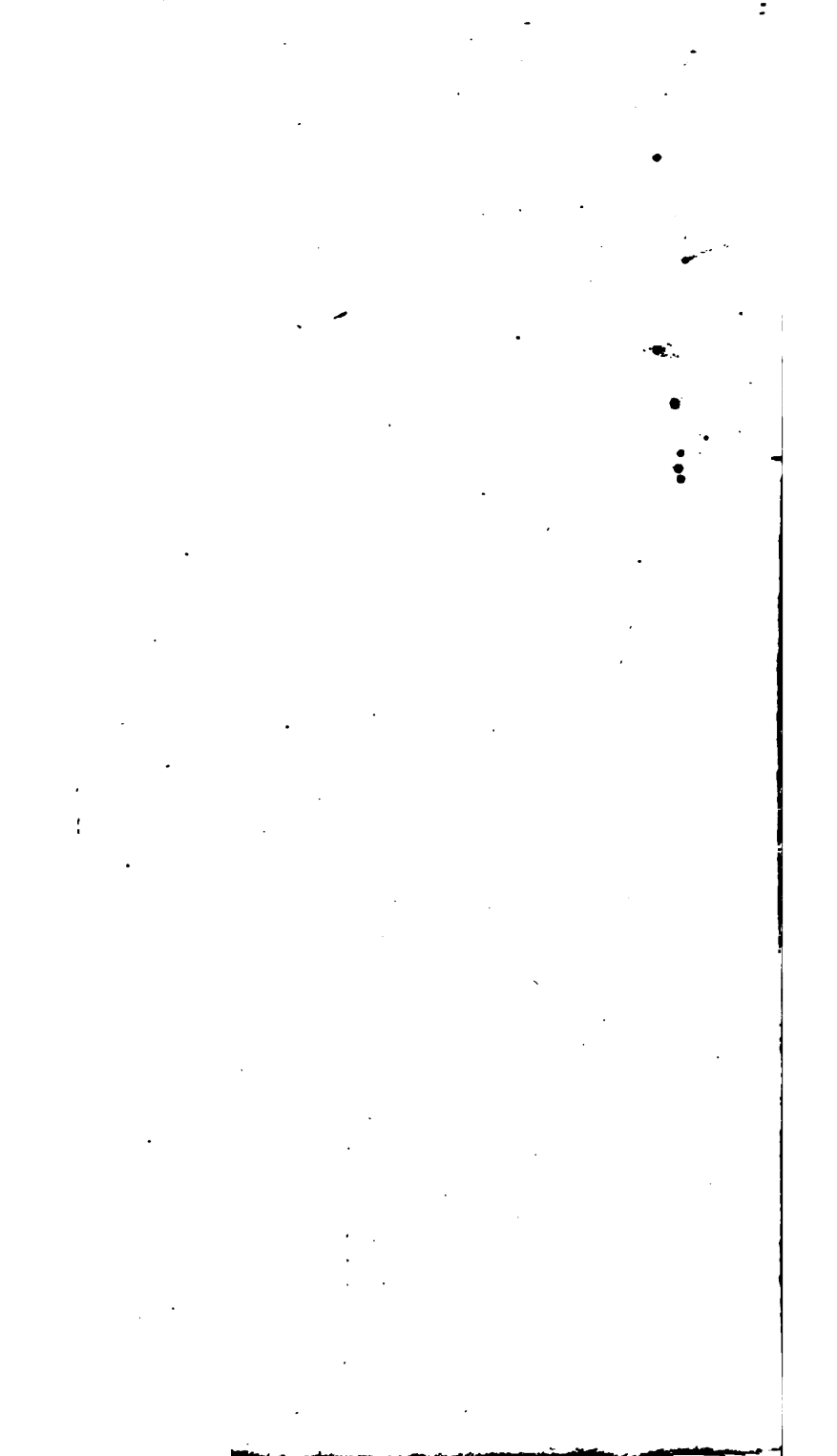




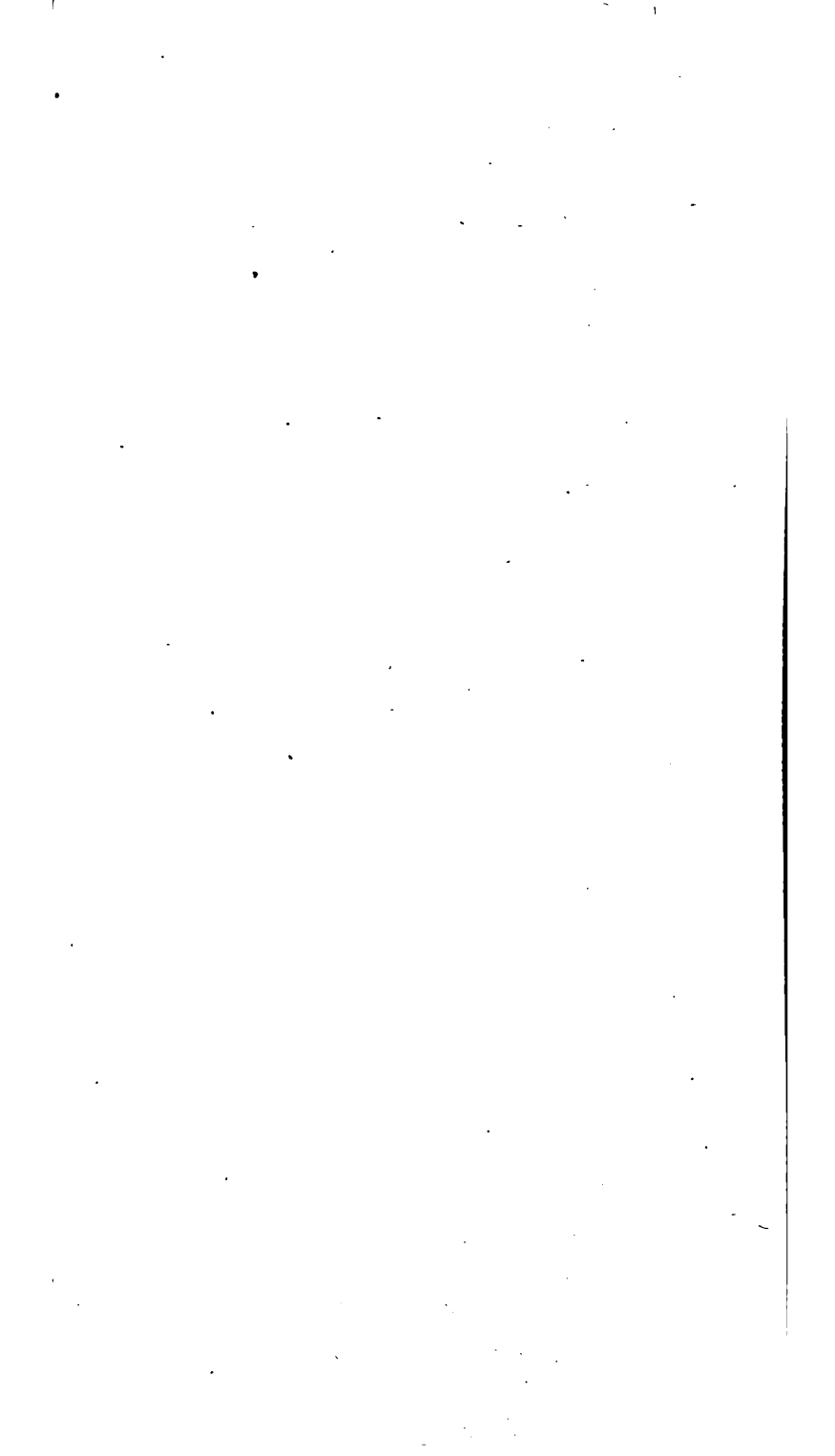


|    |           |                  |       |    |   |    |    |            |
|----|-----------|------------------|-------|----|---|----|----|------------|
| 21 | Noon.     | 40               | 29.05 | 47 | 8 | 7  | 37 | 18, clear. |
|    | Midnight. | 41 $\frac{1}{2}$ |       |    |   |    |    |            |
|    | Noon.     | 39 $\frac{1}{2}$ | 29.06 |    |   | 79 | 57 |            |
| 6  | 6 P. M.   | 41               |       |    |   |    |    |            |









## MISCELLANEOUS OBSERVATIONS.

OBSERVATIONS for determining the refraction in  
high latitudes.

**J**UNE the thirtieth, at midnight, the distance of the two opposite horizons, taken by me with Ramsden's sextant, was  $179^{\circ} 54'$ ; the height of the eye being sixteen feet above the level of the sea.

|   |          |   |   |                           |
|---|----------|---|---|---------------------------|
| August the fifteenth, at midnight, by the astronomical Quadrant, the altitude of the sun's upper limb $4^{\circ} 16' 55''$ lower limb $3^{\circ} 46' 0''$ |          |   |   |                           |
| Error of the Quadrant   | 32       | — | — | 32                        |
|   | <hr/>    |   |   | <hr/>                     |
|   | 4 16 23  | — |   | 3 45 28                   |
| Semidiameter  | — 15 51  | — |   | + 15 51                   |
|   | <hr/>    |   |   | <hr/>                     |
| App. Alt. Sun's center  | 4 0 32   | — |   | 4 1 19                    |
| Co. Declin.   | 75 56 13 | — |   | 75 56 13                  |
|   | <hr/>    |   |   | <hr/>                     |
| App. Lat.   | 79 56 45 | — |   | 79 57 32                  |
| True Lat.   | 79 44 3  | — |   | 79 44 3                   |
|   | <hr/>    |   |   | <hr/>                     |
| Refraction  | 12 42    | — |   | 13 29                     |
| Dr. Bradley's tables  | 11 18    | — |   | 12 27                     |
| Allow for therm.  | 11 53    | — |   | 13 2                      |
| Barometer, 29,6   |          |   |   | Thermometer, $37^{\circ}$ |

M 5

August

August the twentieth, at midnight, the sun's meridian altitude by Mr. Harvey,  $2^{\circ} 25' 00''$

Dip 3 49

---

2 21 11

Semidiameter + 15 52

---

Altitude of the Sun's center 2 37 3

Co. Declin. 77 31 26

---

App. Latitude 80 8 29

Refr. by the tables 16 44

---

True Latitude 79 51 45

---

Hakluyt's Head-land SBE

Cloven Cliff - EBS  $\frac{1}{2}$  S

Variation -  $19^{\circ} 30' S.$

It may not be improper to mention here that Baffin, in 1613, made an observation of the refraction when the sun was in the horizon, in latitude  $78^{\circ} 46'$ , which also agrees exactly with Dr. Bradley's tables. It may therefore be presumed that the refractions in the higher latitudes follow the same law as in these.

Specific

## Specific Gravity of Ice, tried by Dr. Irving.

A piece of the most dense ice he could find, being immersed in snow water, thermometer thirty-four degrees,—fourteen fifteenth parts sunk under the surface of the water.

In brandy just proof, it barely floated: in rectified spirits of wine it fell to the bottom at once, and dissolved immediately.

September the fourth, at two in the afternoon, we sounded with all the lines, above eight hundred fathom. Some time before the last line was out, we perceived a slack, and that it did not run off near so quick as before. When we got the lines in again, the first coil came in very easily, and twenty fathom of the next, after which it took a great strain to move the lead; a mark was put on at the place where the weight was perceived, and the line measured, by which the depth was found to be six hundred and eighty-three fathoms. The lead weighed above one hundred and fifty pounds, and had sunk, as appeared by the line, near ten feet into the ground, which was a very fine blue soft clay. A bottle fitted properly by Dr. Irving (none of those sent out having given satisfaction) was let down, fastened to the line, about two fathom from the lead. A thermometer plunged into the

the water from the bottom stood at forty degrees :  
in water from the surface at fifty-five degrees ;—in  
the shade, the heat of the air was sixty-six degrees.

Experiments to find the Temperature of the Water  
at different Depths, made with Lord Charles Ca-  
vendish's Thermometer.

| Day of the Month. | Depth in Fathoms to which it was sunk. | Temperature of the Water as shown by the Instrument. | Correction for Compression and unequal Expansion of Spirits. | Temperature of the Sea at the greatest Depth to which it was sunk, corrected for Compression and Expansion. | Heat of the Air. |
|-------------------|--|--|--|---|------------------|
|                   |  | °  | °  | °   | °                |
| June 20           | 780                                    | 15   | 11   | 26  | 48½              |
| 30 A. M.          | 118                                    | 30   | 1  | 31  | 40½              |
| P. M.             | 115                                    | 33   | 0  | 33  | 44½              |
| August 31         | 673                                    | 22   | 10   | 32  | 59½              |

It appears from the experiment of July 1st, in which the instrument was compared with Fahrenheit's thermometer at different heats, that the experiment cannot be depended on to less than two or three degrees, as the results drawn from the different comparisons would differ by about five degrees.

Experiments to determine the Temperature of the Water at different Depths of the Sea, and Quantity of Salt it contains; made with the Bottle-fitted by Dr. Irving. A Measure, containing 29 Ounces 59 Grains of pure Snow-water, was used as a Standard; Thermometer 59°, Barometer 30.06.

| Day of the Month. | Weight of the Water. | Depth in Fathoms. | Thermometer at the Surface. | Thermometer in the Water from the Bottom. | Thermometer in the Air. | Weight of the Salt. | Latitude, &c.                                   |
|-------------------|----------------------|-------------------|-----------------------------|---|-------------------------|---------------------|---|
| 1773<br>June 1    | Oz. 29<br>Grs. 404   |                   | °                           | °   | ° 39                    | Grs. 393            | { 51 31 Nore<br>54 8 Off Flambo-<br>rough Head. |
| 9                 | 30 2                 |                   |                             |   |                         | 500                 |   |
| 11                |                      | 32                | 51                          | 49  | 35                      |                     |   |
| { 12 {            | 29 440<br>29 442     | Surface.<br>65    | 50                          | 44  | 50                      | 490                 | { 60 Off Shetland.                              |
| 26                | 29 462               |                   |                             |   | 36                      | 496                 | 74 At Sea.                                      |
| July 3            | 29 454               |                   | 40                          |   | 44                      | 500                 | 78  |
| 19                | 29 369               |                   |                             |   | 44                      | 476                 | 80 Near the Ice.                                |
| Aug. 4            | 30 15                | 60                | 36                          | 39  | 32                      | 510                 | 80 30 Under the Ice.                            |
| 31                | 12 360               | 80                | 51                          |   | 48                      | 220                 |   |
|                   | 12 365               | 683               | 55                          | 40  | 66½                     | 192                 | 75 At Sea.                                      |
| Sept. 4 {         | 12 365               |                   |                             |   |                         | 216                 |   |
| 7                 |                      | 56                | 57                          | 30  | 60                      |                     | 60 14   |



Sea water taken up at the back of Yarmouth Sands, was in the following ratio to distilled water ;

|                 | oz. | dwts. | grs.  |                        |
|-----------------|-----|-------|-------|------------------------|
| Sea-water       | 21  | 16    | 13,77 | } Thermometer,<br>53°; |
| Distilled water | 21  | 4     | 16    |                        |

which is, as 10192 : 10477,7 ; or, as 1 ; 1,02803.

The quantity of dry salt produced from the above water, was 13 dwts. 15 grs. ; it appears, therefore, that sea-water contains more air than distilled water.

The results of the experiments made with Lord Charles Cavendish's thermometer, and those with the bottle fitted by Dr. Irving, differ materially as to the temperature of the sea at great depths ; I shall give an account, therefore, of the precautions used by Dr. Irving to prevent the temperature from being altered, as well as of the allowance made by Mr. Cavendish for compression, as they communicated them to me.

The following is the account of the precautions taken by Dr. Irving to prevent the temperature of the water being changed in bringing up from the bottom :

“ The bottle had a coating of wool, three inches  
 “ thick, which was wrapped up in an oiled skin,  
 “ and let into a leather purse, and the whole inclosed  
 “ in a well-pitched canvas-bag, firmly tied to the  
 “ mouth of the bottle, so that not a drop of water  
 “ could

“ could penetrate to its surface. A bit of lead  
 “ shaped like a cone, with its base downwards and  
 “ a cord fixed to its small end, was put into the  
 “ bottle; and a piece of valve leather, with half a  
 “ dozen slips of thin bladder, were strung on the  
 “ cord, which, when pulled, effectually corked the  
 “ bottle in the inside.”

The following is Mr. Cavendish's account of the  
 corrections to be made for Lord Charles Cavendish's  
 thermometer.

“ The Thermometer used in these experiments  
 “ is fully described in the Philosophical Transactions,  
 “ Vol. L. Page 308; so that I imagine it is unneces-  
 “ sary to mention it here. But since the publication  
 “ of that volume, the late Mr. Canton discovered,  
 “ that spirits of wine and other fluids are compres-  
 “ sible; which must make the thermometer appear  
 “ to have been colder than it really was, and renders  
 “ a correction necessary on that account. There is  
 “ another smaller correction necessary, owing to the  
 “ expansion of spirits of wine by any given number  
 “ of degrees of Fahrenheit's thermometer being  
 “ greater in the higher degrees than the lower. As  
 “ the method of computing these two corrections  
 “ is not explained in that paper, it may be proper  
 “ just to mention the rule which was made use of  
 “ in doing it.

“ In adjusting the degrees on the scale of this  
 “ thermometer, the tube was intirely full of Mer-  
 “ cury,

" cury, or the Mercury stood at no degrees on the  
 " scale, when its real heat was  $65^{\circ}$  of Fahrenheit.  
 " Let the bulk of the Mercury contained at that  
 " time in the cylinder be called  $M$ , and that of the  
 " spirits,  $S$ ; let the expansion of spirits of wine  
 " by  $1^{\circ}$  of Fahrenheit, about the heat of  $65^{\circ}$ ,  
 " be to its whole bulk at that heat, as  $s$  to  
 " 1; and let its expansion by one degree at any  
 " other heat, as  $65^{\circ} - x$ , be to its bulk at  $65^{\circ}$ ,  
 " as  $s \times 1 - x$  to 1; let the expansion of Mercury  
 " by one degree of heat be to its bulk at  $65^{\circ}$ , as  $m$   
 " to 1; and let  $\frac{Ss + Mm}{Ss}$  be called  $G$ ; let the com-  
 " pression of spirits of wine by the pressure of 100  
 " fathom of sea-water, when the heat of the spirits is  
 " nearly the same as that of the sea at the depth to  
 " which the thermometer was let down, be to its  
 " bulk at  $65^{\circ}$ , as  $C$  to 1; the compression of the  
 " Mercury is so small that it may be neglected; let  
 " the thermometer be let down  $N$  hundred fathom,  
 " and when brought up and put into water of  $65^{\circ}$   
 " —  $F$  degrees of heat let the Mercury in the tube  
 " stand at  $E$  degrees; consequently the heat, as  
 " shewn by the thermometer, is  $65^{\circ} - F - E$ ; and let  
 " the real heat of the sea at the depth to which it  
 " was sunk be  $65 - x$  degrees; then  $65^{\circ} - x =$   

$$65^{\circ} - F - E + \frac{CN}{sG} \frac{Ed \times E + F + x}{2G} + \frac{CNd \times F + x}{2sG^2}.$$
 " In this thermometer  $S = 1160$ ;  $M = 97$ ; the  
 " expansion

“ expansion of the spirits used in making it by  $1^{\circ}$  at  
 “ the heat of  $65^{\circ}$ , was found to be  $\frac{1}{1786}$  of their  
 “ bulk at that heat; that is  $s = \frac{1}{1786}$ ;  $m = \frac{1}{11540}$ ;  
 “ therefore  $G = 1,013$ . From M. D Luc's expe-  
 “ riments \* it appears, that the expansion of spirits  
 “ of wine by  $1^{\circ}$  at any degree of heat, as  $65^{\circ}$   
 “ —  $n$ , is to its expansion by  $1^{\circ}$  at  $65^{\circ}$ , nearly as  
 “  $1 - \frac{n}{315}$  to 1: therefore,  $d = \frac{1}{315}$ . The com-  
 “ pressibility of the spirits used for this thermometer  
 “ at the heat of  $58^{\circ}$ , was found to be exactly the  
 “ same as Mr. Canton determines it to be at that  
 “ heat; and therefore its compressibility at all other  
 “ degrees of heat is supposed to be the same as he  
 “ makes it. According to his experiments †, the  
 “ compression of spirits of wine by the pressure of  
 “  $29\frac{1}{2}$  inches of Mercury at the heat of  $32^{\circ}$ , *id est*,  
 “ nearly the heat of the sea in these experiments, is  
 “  $59\frac{1}{2}$  millionth parts of its bulk at that heat;  
 “ therefore  $\frac{C}{G} = 1,9$  and  $65 - n = 65 - F - E$   
 “  $+ N \times 1,9 - \frac{ExE + F + x}{638} + \frac{Nx1,9xF + x}{638}$ .

\* Modifications de l'Atmosphere, vol. I. pag. 252.

† Philosophical Transactions, Vol. LIV. page 261.

**OBSERVATIONS** made by Dr. Irving of the heat of the sea agitated by a gale of wind, and that of the atmosphere.

September the twelfth, the thermometer plunged into a wave of the sea, rose to  $62^{\circ}$ ; the heat of the atmosphere  $50^{\circ}$ .

This experiment was frequently repeated during the gale, and it gave nearly the same difference. At night, when the weather became moderate, the heat of water 30 fathoms below the surface was  $55^{\circ}$ ; the surface and the atmosphere were  $54^{\circ}$ .

September the twenty-second. The sea-water was  $60^{\circ}$ ; the atmosphere,  $59^{\circ}$ : the wind at S W, a fresh gale.

**OBSERVATIONS** for determining the height of a Mountain in Latitude  $79^{\circ} 44'$ ; by the Barometer, and Geometrical Measurement.

Observations taken by the Barometer, by Dr. Irving.

**AUGUST** the eighteenth, the day remarkably clear :

At 6<sup>h</sup> in the morning, the barometer by Inches.  
the sea side stood at 30,040

The Thermometer  $50^{\circ}$

On the summit of the mountain, about an hour and three quarters later than the first observation below, - - 28,266

Thermometer  $42^{\circ}$

About an hour later at the same place 28,258  
Thermometer

# A P P E N D I X. 141

Thermometer  $42^{\circ}$  inches.  
 By the sea side, where the first observation  
 was made, and about three hours later 30,032  
 Thermometer  $44^{\circ}$

|  |         |                   |
|--|---------|-------------------|
| Height of the mountain calculated by M. De Luc |         |                   |
| from the first observation                     | -       | 1585 feet         |
| From the second observation                    | -       | 1592              |
| Mean   | - - - - | <u>1588½ feet</u> |

## Means used to ascertain the Height of the Mountain Geometrically.

A point was fixed upon, in the most convenient place the ground would admit of between the summit of the mountain (a well-defined object) and the sea-side; from hence, in a right line from the mountain, a staff was placed at the sea side, by a Theodolite made by Ramsden, with two telescopes and double Vernier divisions. The instrument was carefully adjusted; first, by levelling the stand with a circular level, and afterwards the whole instrument by the cross levels. From hence (A) at right angles to the station at the sea side (C) and the top of the mountain (E), a base was measured each way to (B) and (D) of eight lines of seventeen fathom each; in all, five hundred and forty-four yards. The divisions of both the Verniers were carefully examined, both at setting off the station by the sea side, and those at the extremities of each base, the fixed telescope

telescope being kept directed to the summit of the mountain, and the moveable one directed at right angles each way, both divisions of the Vernier coinciding exactly. Station staves were fixed perpendicular by the vertical hair of the telescope. The altitude of the mountain was then taken with the vertical arch, as a means of detecting any error in the observation, and was found to be  $8^{\circ} 50'$ . The distance not enabling me to take the depression of any particular part of the staff by the sea side under the land on the other side accurately, I sent a man to stand close before it, and took the depression nearly to his eye, which was found to be  $1^{\circ} 54'$ . The instrument was then removed to the station on the right (B). The instrument being adjusted with the same precautions as before, and the fixed telescope pointing to the center station (A); the angle to the mountain was  $84^{\circ} 58'$ , the angle to the station by the water side (C)  $294^{\circ} 44'$ . The instrument was then removed to the station by the sea side (C), the same precautions used in adjusting, and the fixed telescope pointing to the center (A) in one with the mountain, the angle to the staff on the right (B) was  $24^{\circ} 44'$ . Intending to make the triangle B C D isosceles, and imagining there might be some little error from the unevenness of the ground, I set off the theodolite an angle equal to the last, having a person ready with a staff on the base line to fix it where that angle should intersect on looking through the telescope; I found it cut exactly

exactly at the staff D  $335^{\circ} 16'$ , and from thence concluded the measure of the base to be exact. I then took the altitude of the mountain by the vertical arch  $7^{\circ} 44'$ . I then removed the instrument to the station (D) to take the third angle; but from the badness of the ground, I could not place the instrument exactly over the spot where the staff stood; from hence I took the third angle of the triangle; the fixed telescope pointing to (A) and the same precautions of adjustment being observed, the angle to C came out  $65^{\circ} 15'$ ; less by one minute than it should have been. I then took from the same place the angle to the mountain (E)  $275^{\circ} 1'$ ; more by one minute than the corresponding angle at the opposite station (B): but the errors correcting each other, the whole angle CDE =  $150^{\circ} 14'$  = the whole angle CBE. feet:

By the triangle ABC, AC comes out 1771,4

By the triangle ABE, AE comes out 9265,0

Therefore the distance CE is 11036,4 feet.

Angle of the mountain's elevation seen from C  $7^{\circ} 44'$ :

Height of the mountain above C 1498,8 feet:

+ height of C above the water's edge 5:

Height of the mountain above the water's

edge - - - 1503,8 feet.

I prefer this observation to the others, because the three angles of the triangle ABC came out exactly 180 degrees by the observation. The distance AC found by the computation, differed only four feet from that by the measure; but, the ground being



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being uneven, I did not depend upon the measure, but took it merely as a check upon the operation, to detect an error, in case of any great difference.

The distance found by the similar triangles

B C E and C D E comes out                      11037 feet ;

The angle of the mountain's elevation

seen from A was                      -                       $8^{\circ} 50'$  ;

Hence the height of the mountain above

A was found                      -                      1439,8 feet :

Depression of C seen from A was  $1^{\circ} 54'$  ;

Hence the height of A above C is                      58,7

Height of the mountain above C                      1498,5

+ height of C above water's edge                      5 ;

Height of mountain above the level of

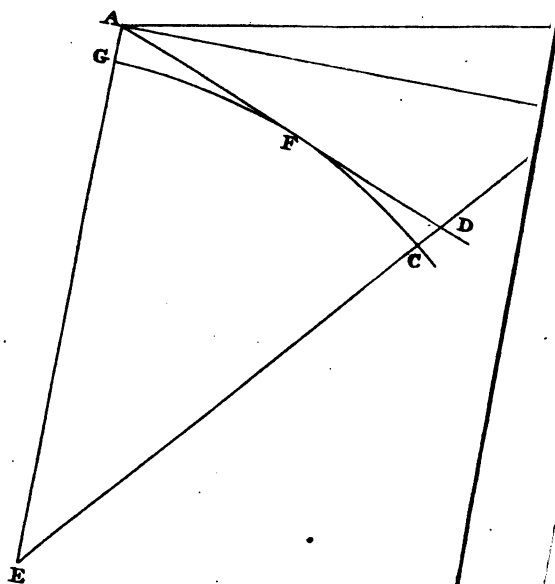
the sea                      -                      -                      1503,5

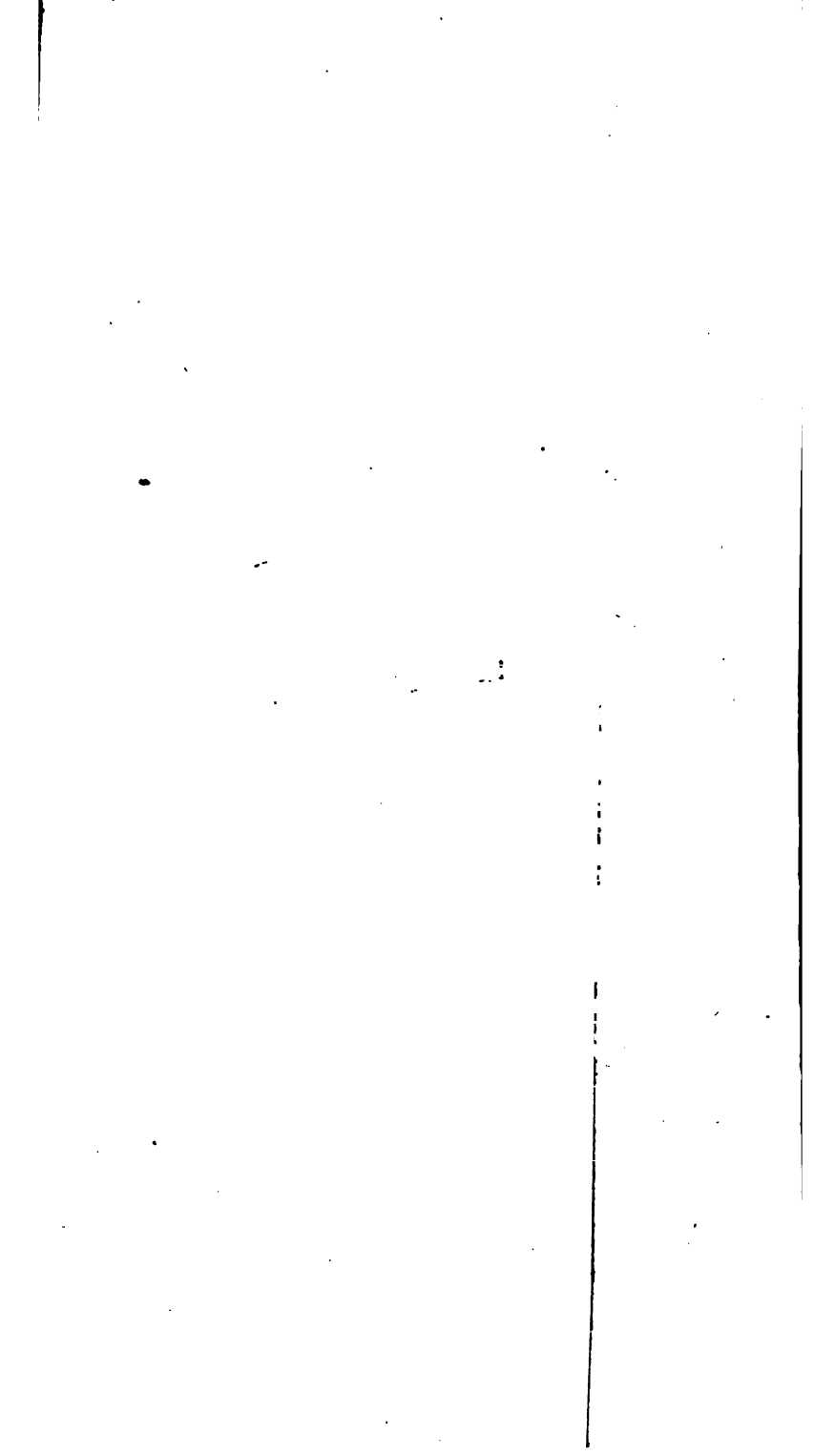
which differs from that found by the single angle three tenths of a foot.

I cannot account for the great difference between the geometrical measure and the barometrical one according to M. De Luc's calculation, which amounts to 84,7 feet. I have no reason to doubt the accuracy of Dr. Irving's observations, which were taken with great care. As to the geometrical measure, the agreement of so many triangles, each of which must have detected even the smallest error, is the most satisfactory proof of its correctness. Since my return, I have tried both the theodolite and barometer, to discover whether there was any fault in either, and find them upon trial, as I had always done before, very accurate.

OBSERVATIONS

Fig.1.





# OBSERVATIONS for determining the Acceleration of the PENDULUM.

Description of the Pendulum with which the Observations were made, by Mr. Cumming.

“THE apparatus with which the following  
“ experiments were made, was prepared for  
“ the voyage with all the care which the shortness  
“ of the time would admit, and particular atten-  
“ tion was paid to its simplicity. The pendulum  
“ was that which the late Mr. George Graham  
“ had constructed, to ascertain the exact distance  
“ between the center of motion and center of  
“ oscillation of a pendulum to vibrate seconds at  
“ London.

“ The ball is a sphere of solid brass, whose dia-  
“ meter is three inches and ninety two hundredth  
“ parts of an inch, and whose weight is nine pounds  
“ and one quarter.

“ The rod is a round steel wire, one tenth of  
“ an inch thick, and is so firmly screwed into the  
“ ball, that it cannot be unscrewed by hand, nor  
“ the length of the pendulum altered without the  
“ application of proper instruments for that purpose,  
“ there being no adjusting screw as in clock-pen-  
“ dulum.

“ The axis of the pendulum is of hard-tempered  
“ steel, nearly two inches long, and moves on an-  
“ gular, or knife-pivots, whose edges are formed

N

“ with

“ with great care, so as to lie exactly in the same  
“ right line; the pivots are formed nearly to an  
“ angle of thirty-eight degrees from the edge to  
“ the back; the sharpness of the edges is taken off,  
“ and they are carefully rounded, so that the  
“ lower parts of both (on which the pendulum  
“ moves) form parts of one continued cylinder,  
“ whose diameter is rather less than the two hundredth part of an inch.

“ Those pivots move in angular notches made  
“ in two pieces of hardened steel, each a quarter  
“ of an inch thick; the notches are formed to an  
“ angle of one hundred and twenty degrees, with  
“ their bottoms somewhat rounding, and formed  
“ so that the whole length of the pivot has an equal  
“ bearing in them; the ends or extremities of the  
“ pivots are sloped from the edges on which they  
“ move, towards the backs, or upper side; and  
“ two plates of hardened steel are screwed against  
“ the angular notches in which the pivots move, so  
“ as to confine them always to the same place in the  
“ notches, and prevent such irregularities as might  
“ otherwise happen if the shoulders of the pivots  
“ should chance to touch.

“ Towards one end of the axis is pierced an oblong square hole, from the upper to the under  
“ side, into which the upper end of the pendulum  
“ rod (having its sides somewhat flattened) is fitted,  
“ without shake, but in such manner that it moves  
“ freely therein from back to front, round a steel

“ pin

" pin which passes horizontally through it and the  
 " axis, that both the pivots may have an equal bear-  
 " ing, and the pendulum may hang truly perpen-  
 " dicular, without any tendency to bend its rod, and  
 " by that means alter its time of vibration, even  
 " though the axis be not accurately adjusted to a  
 " level position: The error which might arise from  
 " accidental friction on the above supposition, of an  
 " inaccurate levelling of the axis, is obviated by  
 " means of the steel plates against which the *very*  
 " *central point* of the lowest pivot must in such case  
 " act.

" To the other end of the axis, is screwed a pair  
 " of pallets, constructed nearly on Mr. Graham's  
 " principle of the *dead-beat*, but differing from it  
 " in having a degree of recoil which tends to ren-  
 " der the longer vibrations of the pendulum as  
 " quick as the shorter: but this precaution is the  
 " less necessary, because the weight which keeps  
 " the machine in motion is so adjusted, as to make  
 " the angle of constant vibrations as nearly as  
 " possible the same with the angle of scapement;  
 " that is, to make the vibrations the shortest, that  
 " will admit of the wheel to escape the pallets: by  
 " this means, if the oil applied should become  
 " glutinous, so as to diminish the action of the  
 " wheel on the pendulum, or if any other circum-  
 " stance should happen to shorten the arc of vi-  
 " bration of the pendulum, the weight which  
 " keeps it in motion must be increased, till it is

“ found juſt ſufficient to keep the machine going;  
“ by which means there is a certainty that the pen-  
“ dulum vibrates ſimilar arcs in each experiment,  
“ even if the obſerver ſhould not attend to that  
“ circumſtance.

“ The ſwing-wheel is made of tempered ſteel,  
“ and the points of its teeth are left much thicker  
“ than they uſually are in clocks, in order to avoid  
“ accidents; it has thirty teeth, and carries with  
“ it a divided circle which ſhews ſeconds.

“ On the axis of the ſwing-wheel there is a pi-  
“ nion, on which another wheel acts: and in the  
“ axis of this laſt, there is a ſmall pulley, in the  
“ groove of which is applied the line which keeps  
“ the machine going, by means of a weight and  
“ counter-weight, in the manner deſcribed by  
“ Huygens in the eighth and eighteenth pages of  
“ his *Horologium oſcillatorium*: this method is the  
“ ſimpleſt of any for keeping the wheels in motion  
“ while the weight is winding up, and is pecu-  
“ liarly advantageous in ſuch machines as this, which  
“ require frequent winding: the weight applied  
“ to this machine was ſix ounces Troy, which with  
“ a deſcent of thirty-two inches kept it going for  
“ three hours, with a vibration of three degrees.

“ The whole is contained in a ſtrong braſs frame,  
“ ſcrewed on the top of a three-legged wooden  
“ ſtand, three feet four inches high: the front  
“ legs extend three feet eight inches in the direc-  
“ tion of the vibration, and the back leg extends  
“ three

“ three feet four inches from each of the front  
 “ legs, at which distance the three legs are so  
 “ connected at bottom, by horizontal rods, that  
 “ they cannot possibly alter their relative position;  
 “ by these means the point of suspension of the  
 “ pendulum is rendered much more immoveable  
 “ than could be done in any portable clock having  
 “ a case of the usual dimensions, without great  
 “ trouble, and an apparatus ill suited for experiments  
 “ of this nature.

“ In the middle of the horizontal bar that con-  
 “ nects the front legs is fixed a piece of silvered-  
 “ glass, by means of which the whole machine is  
 “ readily adjusted to its proper position: the lower  
 “ part of the pendulum-ball hangs directly over  
 “ this mirror, on which is drawn a line from back  
 “ to front; and when the image of a small pin,  
 “ which is screwed into the lower part of the pen-  
 “ dulum, is seen bisected by this line viewed di-  
 “ rectly in front, the position of the machine is  
 “ properly adjusted.

“ On the back leg of the stand, immediately be-  
 “ hind the pendulum, is a hook to hang a ther-  
 “ mometer on, for making frequent observations  
 “ of the temperature of the air. In order to pre-  
 “ pare for an experiment, the pendulum is made  
 “ to vibrate till 60 on the second-circle comes to the  
 “ index, and is then to be held at the extremity



“ of its vibration by a trigger ; on pressing which  
“ with the finger, the pendulum is disengaged in  
“ an instant : hence the vibrations must be of equal  
“ extent in every experiment.

“ The wooden stand which supports the pen-  
“ dulum is so constructed, that it forms an oblong  
“ square box, in which the pendulum, with every  
“ part of its apparatus, is with great facility and  
“ expedition packed ; so securely that no part can  
“ receive damage ; and the whole is so portable,  
“ that it may with ease be carried on a man’s  
“ shoulder to any accessible place.

“ This pendulum immediately before the voyage  
“ was compared with a well-regulated eight-day  
“ clock, and in twelve hours its beat did not dif-  
“ fer sensibly from that of the clock ; Fahrenheit’s  
“ thermometer being then at 60°.”

July the sixteenth the Pendulum and the Equatorial Instrument were landed on a small rocky island in latitude 79° 50' N ; and the pendulum being carefully set up in a small tent erected for that purpose, and its position truly adjusted, a thermometer was suspended on the hook behind the pendulum rod ; and the pendulum being repeatedly put in motion, it was found to stop, till a musket bullet and a half was added to the weight, which was found sufficient to keep it in motion ;  
when

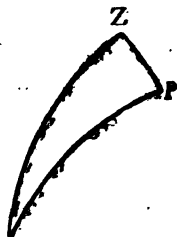
when it was thus found to continue its vibration, it was locked by the trigger at  $60''$ . The equatorial instrument was set up on a basis of solid rock, and being in this case to be used only as a transit instrument, no attempt was made to adjust it either to the latitude or meridian of the place; but the azimuth and equatorial circles being truly levelled, the telescope was directed towards the sun, and so elevated that it should pass as near as possible through the middle of the field. The instrument being thus prepared, the West limb of the sun was observed to touch the East side of the vertical wire in the telescope at  $5^h 19' 28''$  in the afternoon, by the watch; and at the same instant the pendulum was unlocked, and kept vibrating till after the sun had completed its revolution, and its West limb was again seen to touch the same side of the vertical wire.

From the vertical position of the wire and the time of the day, the sun's motion had a degree of obliquity with respect to the wire, which must occasion its diameter to take a longer time in passing than if it crossed the wire at right angles: this position of the wire, together with the change of the sun's declination, prolong the time of the sun's coming again to the wire; so that there was an interval of twenty-four hours, forty-nine seconds and a half, from the time that the sun's limb touched the wire on the sixteenth day of July, to the time

of its return to the same wire on the seventeenth day\*.

During the time of this revolution of the sun, an account was kept of the thermometer, and several comparisons made of the rate of the going of the pendulum with my second-watch: in making which, I always took the time by the watch, when the pendulum shewed 60": these comparisons were chiefly intended to prevent a mistake of a whole minute in estimating the acceleration of the pendulum, which only shewed seconds, having no index

\* July the sixteenth P. M. at 5<sup>h</sup> 19' 28" by the watch: the angle S between the vertical circle of declination was 10° 49': the sun's altitude 20°; its declination 21° 8': the change in the sun's declination in 24<sup>h</sup>, was 10' 11": hence the time of the sun's coming to the same vertical hair of a telescope, will be retarded 44",1: for (by Cotes, S



*Estimatio Errorum, Theor. 35.*)

|  |   |                  |
|--|---|------------------|
| As sine Z P or cosine latitude,              | — | Com. Ar. 0,75322 |
| Is to tang. S. 10° 49';                      | — | 9,28117          |
| So is the change in declin. 10' 11" sine,    |   | 7,47161          |
| To 11' 4" the change in the hor. angle sine, |   | 7,50600          |
| Which turned into time, gives                | — | 44",1            |
| The change in the equation of time is        |   | 5.4              |

|   |   |                         |
|---|---|-------------------------|
| Therefore the interval between the two }<br>transits is |   | 24 <sup>h</sup> 0' 49.5 |
| It was observed   | — | 24 (2) 4.5              |
| The difference is the gain of the pendulum              |   | (1) 15                  |

To

index for minutes: and as a candid investigation of a matter that had so much engaged the attention of the best philosophers and mathematicians was the only object of my wish, I judged it best, in the first place, to give the observations just as they were made; regularly numbered, that they may be readily referred to from the following tables, in which the order of the original observations is varied, according to the periods of time between each pair of observations. By thus giving the foundations on which the conclusions depend, all persons, who chuse it, may trace and examine every step towards the conclusion, and by that means be enabled to detect any error that may have crept into the operation; or draw such further conclusions as their ingenuity may suggest, and the materials here given may warrant.

To find the time of the sun's diameter passing a vertical hair, (Cotes, *Astr. Recur. Theor.* 21.)

|   |  |                   |
|---|--|-------------------|
| As the product of                                     | { Confin'd declination   | Comp. Ar. 0,03024 |
|   | { Confin'd S.  | Comp. Ar. 0,00778 |
| Is to the product of Radius and Cos. Altitude;        |  | 19,97298          |
| So is the sun's diameter in time 135 <sup>h</sup> ,6, |  | <u>2,13226</u>    |
| To the time sought                                    | 139 <sup>h</sup> ,1 <sup>m</sup> 2 <sup>s</sup> 19 <sup>s</sup> ,1 | <u>2,14326</u>    |
| It was observed                                       | 2' 21 <sup>h</sup> ,9  |                   |
| Difference  | 1 <sup>h</sup> ,9  |                   |

Although the observation of the sun's diameter passing the wire has no immediate connection with our conclusion; yet the agreement between the calculated and the observed time of its passing, serves to show that the proper allowance was made for the obliquity of the direction in which it passed the wire.

Day

| Day of the<br>Month. | No. | Time by the<br>Watch. | Time by the<br>Pendulum. | Thermo-<br>meter. | Remarks.               |
|----------------------|-----|-----------------------|--------------------------|-------------------|------------------------|
|                      |     | h ' "                 | "                        |                   |                        |
| July 16 }<br>P. M. } | 1   | 5 19 28               | 60                       | 50                | { Equatorial<br>fixed. |
|                      | 2   | 6 30 00               | . .                      | 49 $\frac{1}{2}$  |                        |
|                      | 3   | 7 00 00               | . .                      | 50                |                        |
|                      | 4   | 8 00 00               | . .                      | 49                |                        |
|                      | 5   | 8 30 00               | . .                      | 49                |                        |
|                      | 6   | 9 00 00               | . .                      | 45                |                        |
|                      | 7   | 9 30 00               | . .                      | 45                |                        |
|                      | 8   | 10 00 00              | . .                      | 45                |                        |
|                      | 9   | 11 00 00              | . .                      | 45                |                        |
|                      | 10  | 11 30 00              | . .                      | 48 $\frac{1}{2}$  |                        |
|                      | 11  | 12 00 00              | . .                      | 48 $\frac{1}{2}$  |                        |
|                      | 12  | 12 30 00              | . .                      | 46                |                        |
|                      | 13  | 12 39 14              | 60                       | 51                |                        |
| 17 A. M.             | 14  | 1 00 00               | . .                      | 50 $\frac{1}{2}$  | {                      |
|                      | 15  | 2 55 9                | 60                       | 49                |                        |
|                      | 16  | 5 00 00               | . .                      | 45                |                        |
|                      | 17  | 6 00 00               | . .                      | 44                |                        |
|                      | 18  | 7 00 00               | . .                      | 49 $\frac{1}{2}$  |                        |
|                      | 19  | 8 00 00               | . .                      | 47                |                        |
|                      | 20  | 9 00 00               | . .                      | 49 $\frac{1}{2}$  |                        |
|                      | 21  | 11 2 23               | 60                       | 58 $\frac{1}{2}$  |                        |
|                      | 22  | 12 00 20              | 60                       | 56                |                        |
| P. M.                | 23  | 1 00 00               | . .                      | 54                |                        |
|                      | 24  | 2 30 00               | . .                      | 52 $\frac{1}{2}$  |                        |
|                      | 25  | 3 30 00               | . .                      | 56                |                        |
|                      | 26  | 4 00 00               | . .                      | 55 $\frac{1}{2}$  |                        |
|                      | 27  | 4 46 10 $\frac{1}{2}$ | 60                       | 52 $\frac{1}{2}$  |                        |
|                      | 28  | [5 19 24]             | 4 $\frac{1}{2}$          |                   |                        |
|                      | 29  | . . .                 | 25                       |                   |                        |
|                      | 30  | 5 24 9                | 60                       | 51                |                        |

Transit of  
the Sun's  
W. limb.

Transit of  
the Sun's  
E. limb.

It has already been said that the watch was used only to prevent an error of *whole minutes*, in estimating the time gained by the pendulum in twenty-four hours; the exact period of twenty-four hours being determined by the revolution of the sun.

In order to obtain the acceleration of the pendulum, the original observations are transferred from the foregoing table, to that which follows, for the convenience of arranging them according to the length of the intervals, beginning with those of the shortest duration: so that the conclusion from each period becomes a check upon those that follow.

In this table *the first column* refers to the original observations, from which a conclusion is here to be drawn; thus, in the first line, we find 27—30, by which is meant that a conclusion is to be drawn in this line from observations 27 and 30, that is, from the acceleration of the pendulum from four hours, forty-six minutes, ten seconds and a half, to five hours, twenty-four minutes nine seconds in the afternoon, July 17.

*The second column* expresses the interval of time by the watch, between each pair of observations referred to in the first.

*The third column* shews how much the pendulum gained on the watch, in each period expressed in the second.

*The fourth column* shews the mean height of the Thermometer for each period. *The*

*The fifth column* expresses the difference between this mean height, and  $60^{\circ}$ , the height of the thermometer at London when the pendulum was adjusted.

*The sixth column* shews the contraction of the pendulum rod by the degree of cold expressed in the fifth column, according to Mr. Smeaton's experiments, published in N<sup>o</sup> 79 of the Philosophical Transactions for the year 1754.

*The seventh column* shows how much this contraction would make the pendulum gain during each period of the second column.

*The eighth column* shews how much the pendulum would have gained on the watch in each period, if the thermometer had remained at  $60^{\circ}$ , and therefore no contraction of the pendulum-rod had taken place.

*The ninth column* shows how much the watch ought to have lost in each period, allowing it to have lost uniformly at the rate of four seconds in twenty-four hours, as was observed by the transit.

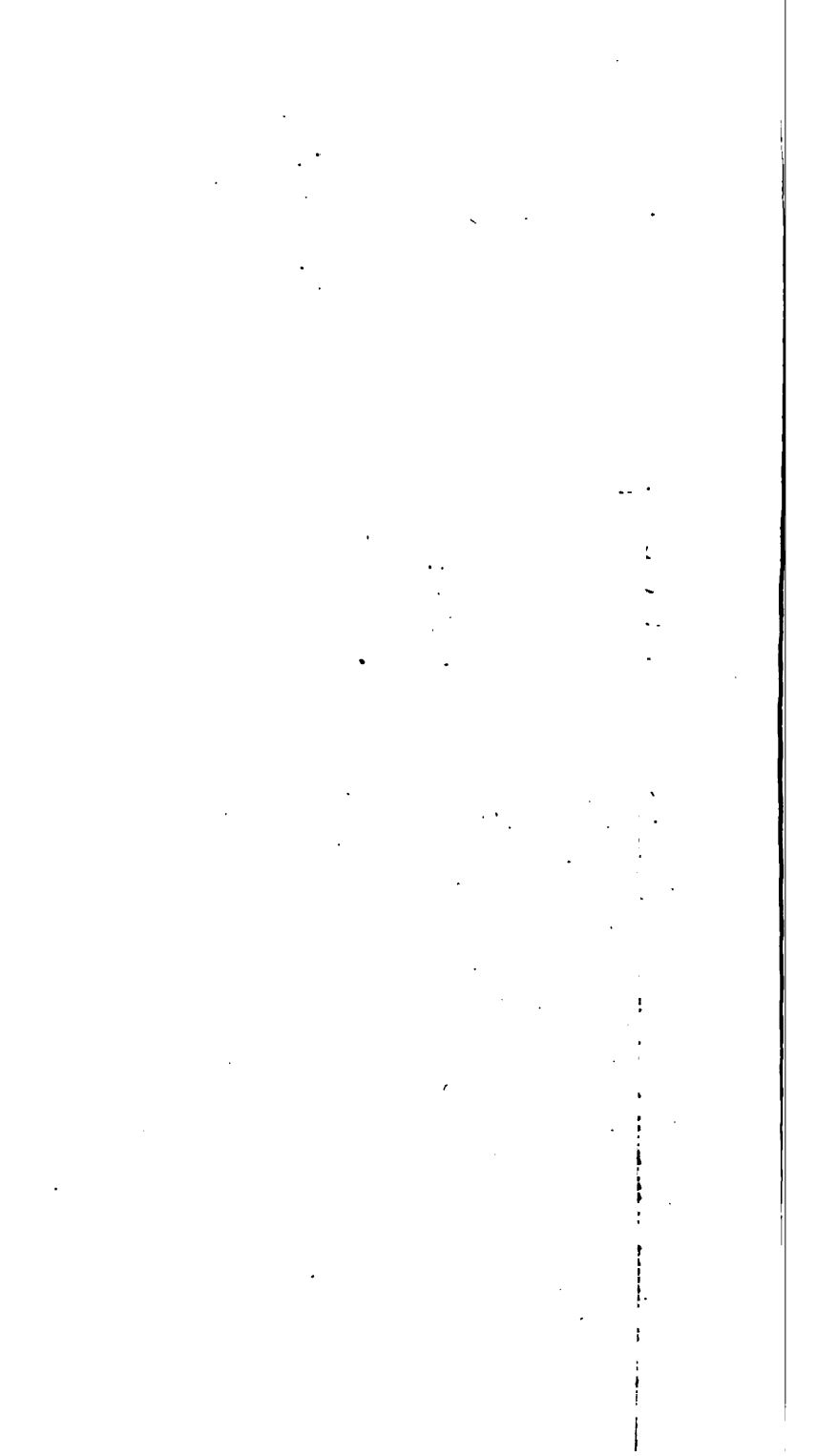
*The tenth column* shews how much the pendulum would have gained on the watch, in each period; allowing for its losing at the rate of four seconds in twenty-four hours, and supposing the thermometer to have remained constantly at  $60^{\circ}$ .

*The eleventh column* shews how much the pendulum would gain *per hour* according to the rate of acceleration given in the tenth column for each period.

## Observations with the Pendulum from the

| 1<br>Observations<br>referred to. | 2<br>Duration in<br>Time by the<br>Watch. | 3<br>Seconds<br>gained by<br>the Pendu-<br>lum on the<br>Watch. | 4<br>Mean<br>Height<br>of the<br>Ther-<br>mome-<br>ter. | 5<br>Difference between<br>the Height of the<br>Thermometer at<br>the Time of Ad-<br>justment at Lon-<br>don, and the Time<br>of Observation. |
|-----------------------------------|---|---|---|---|
|                                   | H ' "                                     | "   | °   | °   |
| 27—30                             | 0 37 58½                                  | 1½  | 52  | 8   |
| 21—22                             | 0 57 57                                   | 3   | 57  | 3   |
| 13—15                             | 2 15 55                                   | 5   | 49¼   | 10¾   |
| 22—27                             | 4 45 50½                                  | 9½  | 53¾   | 6¾  |
| 22—30                             | 5 23 49                                   | 11  | 53  | 7   |
| 21—27                             | 5 43 47½                                  | 12½   | 54½   | 5½  |
| 21—30                             | 6 21 46                                   | 14  | 54½   | 5½  |
| 1—13                              | 7 19 46                                   | 14  | 47½   | 12½   |
| 15—21                             | 8 7 14                                    | 46  | 48¾   | 11¼   |
| 15—22                             | 9 5 11                                    | 49  | 50¾   | 9¾  |
| 1—15                              | 9 35 41                                   | 19  | 48  | 12  |
| 13—21                             | 10 23 9                                   | 51  | 49½   | 10½   |
| 13—22                             | 11 21 6                                   | 54  | 50  | 10  |
| 15—27                             | 13 51 1½                                  | 58½   | 52  | 8   |
| 15—30                             | 14 29 0                                   | 60  | 51¾   | 8¾  |
| 13—27                             | 16 6 56½                                  | 63½   | 54  | 6   |
| 13—30                             | 16 44 55                                  | 65  | 53¾   | 6¾  |
| 1—21                              | 17 42 55                                  | 65  | 48¾   | 11¼   |
| 1—22                              | 18 40 52                                  | 68  | 49¼   | 10¾   |
| 1—27                              | 23 26 42½                                 | 77½   | 50½   | 9½  |
| 1—30                              | 24 4 41                                   | 79  | 50¼   | 9¾  |





It appears by the original observations that the pendulum began its vibrations at 60", the instant in which the first limb of the sun was observed to touch the side of the vertical wire in the telescope of the Equatorial, that is, at five hours, nineteen minutes, twenty-eight seconds in the afternoon by the watch, on the 16th of July; and by every comparison of the pendulum with the watch, that the pendulum was constantly gaining on the watch, and in a period of twenty-four hours, four minutes, forty-one seconds, had gained on the watch seventy-nine seconds; and when the revolution of the sun was completed, it appeared, that the watch had lost four seconds in the exact period of twenty-four hours; therefore, if four seconds lost by the watch, be subtracted from seventy-nine, the time gained by the pendulum on the watch, it will leave seventy-five seconds for the time gained by the pendulum on the *mean*, or true time, no deduction being here made for the contraction of the pendulum rod by the cold.

The odd fifteen seconds are determined by observing, that the pendulum showed four seconds and a half exactly when the sun had again returned to the vertical wire; so that this period is determined wholly by the sun, and totally independent of the watch; but as the watch is found by the same observation to have lost only four seconds, recourse is had to the intermediate comparisons of it with the pendulum, which clearly show that the  
pendulum

pendulum had gained *one whole minute*, together with the fifteen seconds determined by the pendulum and the revolution of the sun: and although it appears by the eleventh column of the foregoing table that the watch did not lose uniformly at the rate of four seconds in twenty-four hours, yet its mean rate leaves as little doubt with regard to the *whole minute* gained by the pendulum, as if its going had been perfectly uniform during the whole time. For, if from the sum of all the periods in the second column, and of all the accelerations in the tenth, a mean rate be taken, it makes the acceleration of the pendulum on the watch to be  $80''$   $79$  in twenty-four hours, which differs from the acceleration observed by the revolution of the sun only  $5''$   $75$ ; and from the rate of going of the watch, determined by the revolution of the sun, only  $1''$   $79$ : hence there can be no possible room to suppose an error of a whole minute.

Although the period of twenty-four hours, and the rate of going of the watch for that time, are very accurately determined by the revolution of the sun; it may not be improper here to take notice, that from a mean of six altitudes of the sun, taken by a very good astronomical quadrant of eighteen inches radius, the watch was computed to have lost  $5''\frac{1}{2}$ , in twenty four hours, which differs from the rate given by the revolution of the sun only  $1''\frac{1}{2}$ ; this may serve to shew how far the mean of a great number of observations by the same

same observer and instrument may be relied on, when there is no other observation to check or corroborate.

It may also be proper here to mention, that the time by the watch was not observed at the instant that the sun had returned to the vertical wire, and at which the pendulum was observed to show  $4\frac{1}{2}$  seconds, my attention being wholly engaged in observing the pendulum. The watch was found to have lost  $77''\frac{1}{2}$  by the pendulum, in twenty-three hours, twenty-six minutes, forty-two seconds and a half. An allowance according to this rate for  $34' 4''$  (the supplement of the last observation by the watch to the time of the sun's passage when the pendulum shewed  $4''\frac{1}{2}$ ) amounts to  $1''\frac{1}{2}$ .

From whence it follows, that the West limb of the sun touched the East side of the vertical hair at five hours, twenty minutes, thirteen seconds and a half, by the watch; which had therefore lost four seconds in twenty-four hours.

As the comparison of the watch and the pendulum in this one instance is not from actual observation, *at the instant*, but supposes that the watch had kept for thirty-four minutes to the same rate of losing at which it had been observed to lose for nearly twenty-four hours immediately preceding; the time by the watch *thus found* is inserted in the table of observations within hooks to distinguish it, that every person may have an opportunity

tunity of judging how far it ought to be admitted. Upon the whole it appears, that by the revolution of the sun, corrected for the oblique direction in which it passed the vertical wire in the telescope, the change of declination and the equation from the time of its West limb touching the wire on the 16th, to the time of its touching the same wire on the 17th of July, that the pendulum gained seventy-five seconds in twenty-four hours. But as the mean height of the thermometer for the time of this experiment was  $90^{\circ}\frac{1}{2}$  lower than  $60^{\circ}$ , the height at which it was at London when the pendulum was compared with the clock, the pendulum ought on this account, according to Mr. Smeaton's experiments, to have been contracted  $\frac{1\frac{1}{2}}{10000}$  of an inch, and to have gained on that account  $2,^{\circ}72$ ; so that the acceleration of the pendulum arising only from the difference between the latitude of London and  $79^{\circ} 50' N$ , is  $72^{\circ},28$ .

The pendulum was continued in motion, and the comparisons between it and the watch made as before, with intention to take a second revolution of the sun: but at eleven o'clock next morning, the wind being fair, and the weather cloudy so as to afford no prospect of seeing the sun in the afternoon, the instruments were taken on board, and the ships sailed immediately.

August

August the fourteenth, we landed the Pendulum, Equatorial Instrument, and astronomical Quadrant on Smeerenberg Point, latitude  $79^{\circ} 44'$  N; and set up the pendulum in every respect as formerly described. The equatorial and quadrant were also set up, and prepared for observation.

The pendulum was set a going when it was exactly  $6^h 0' 0''$  P. M. by my watch, from which time it was frequently compared with the watch, till  $5^h 50'$  A. M. the 15th; when the pendulum stopped. It was again set a going with the additional weight which had formerly been used, when the watch was exactly  $6^h 00' 00''$ , and continued going from that time till after five in the morning of the 18th, in which time the thermometer was observed, and the watch and pendulum compared, as in the following table: many altitudes of the sun were taken with the quadrant, on the 15th A. M. but without any further opportunity till the 18th A. M. when they were repeated to ascertain the rate of the watch's losing.

O

Day

| Day of the Month.     | N <sup>o</sup> | Time by the Watch.     | Time by Pendulum. | Thermom.         | Remarks.   |
|-----------------------|----------------|------------------------|-------------------|------------------|--|
|                       |                | h ' "                  | "                 | °                |  |
| Aug. 14th, }<br>P. M. | 1              | 6 00 00                | 60                | 44               |  |
|                       | 2              | 7 29 53 $\frac{1}{2}$  | 60                | 43               |  |
|                       | 3              | 12 13 30 $\frac{1}{2}$ | 60                | 40               |  |
| 15th A. M.            | 4              | 5 00 09                | 60                | 36               | The Pendulum set ago-<br>ing with the<br>additional<br>Weight. |
|                       | 5              | 6 03 00                | 60                | 35               |  |
| P. M.                 | 6              | 2 09 22 $\frac{1}{2}$  | 60                | 36               |  |
|                       | 7              | 8 59 49                | 60                | 37               |  |
| 16th, A. M.           | 8              | 2 00 00                | .                 | 36 $\frac{1}{2}$ |  |
|                       | 9              | 3 00 00                | .                 | 37               |  |
|                       | 10             | 4 00 00                | .                 | 36               |  |
|                       | 11             | 5 00 00                | .                 | 37               |  |
|                       | 12             | 6 00 00                | .                 | 36 $\frac{1}{2}$ |  |
|                       | 13             | 7 00 00                | .                 | 37               |  |
|                       | 14             | 8 00 00                | .                 | 37               |  |
|                       | 15             | 9 00 00                | .                 | 37               |  |
|                       | 16             | 10 00 00               | .                 | 37               |  |
|                       | 17             | 11 00 00               | .                 | 37               |  |
| Noon                  | 18             | 12 00 00               | .                 | 37               |  |
| P. M.                 | 19             | 1 00 00                | .                 | 37               |  |
|                       | 20             | 2 01 39 $\frac{1}{2}$  | 60                | 37               |  |
|                       | 21             | 3 01 34 $\frac{1}{2}$  | 60                | 37               |  |

| Day of the Month.   | N <sup>o</sup> | Time by the Watch. |    |                  | Time by Ther-<br>Pendulum mon. | Remarks.         |
|---|----------------|--------------------|----|------------------|--------------------------------|------------------|
|   |                | h                  | '  | "                | "                              |                  |
|   | 22             | 7                  | 13 | 16               | 60                             | 38               |
|   | 23             | 9                  | 00 | 00               | .                              | 38               |
|   | 24             | 10                 | 00 | 00               | .                              | 37 $\frac{1}{2}$ |
|   | 25             | 11                 | 00 | 57               | 60                             | 37               |
| Midnight,   | 26             | 12                 | 00 | 00               | .                              | 38               |
| Aug. 17th, }<br>A. M. }   | 27             | 1                  | 00 | 00               | .                              | 38               |
|   | 28             | 2                  | 00 | 00               | .                              | 38               |
|   | 29             | 3                  | 00 | 00               | .                              | 38               |
|   | 30             | 4                  | 00 | 00               | .                              | 37 $\frac{1}{2}$ |
|   | 31             | 5                  | 00 | 00               | .                              | 37 $\frac{1}{2}$ |
|   | 32             | 6                  | 00 | 00               | .                              | 38               |
|   | 33             | 7                  | 00 | 00               | .                              | 37 $\frac{1}{2}$ |
|   | 34             | 8                  | 00 | 00               | .                              | 37 $\frac{3}{4}$ |
| Noon  | 35             | 9                  | 00 | 00               | .                              | 37 $\frac{1}{2}$ |
| P. M.   | 36             | 10                 | 00 | 00               | .                              | 38 $\frac{1}{2}$ |
|   | 37             | 11                 | 00 | 00               | .                              | 37               |
|   | 38             | 12                 | 00 | 00               | .                              | 39 $\frac{1}{2}$ |
|   | 39             | 1                  | 00 | 00               | .                              | 40               |
|   | 40             | 2                  | 02 | 58               | 60                             | 41               |
|   | 41             | 4                  | 23 | 45 $\frac{1}{2}$ | 60                             | 40               |
|   | 42             | 10                 | 00 | 19 $\frac{1}{2}$ | 60                             | 39               |
| Between five and six in the morning of the eighteenth,<br>it blew hard, and the Pendulum stopped. |                |                    |    |                  |                                |                  |



The following table is constructed in every respect the same as that described page 155, and differs from it only in having an *additional column*, in which is given the rate of acceleration of the Pendulum in twenty-four hours, according to the time by the watch, corrected by a mean of sixteen altitudes of the sun taken on the 15th, and a mean of thirty-nine altitudes on the 18th of August, from which the watch appears to have lost, during the interval of the three days, at the rate of  $23''\cdot7$  per day. The rate of acceleration of the pendulum in twenty-four hours being thus determined, agreeable to the acceleration observed in each of the last eight periods, being those of the longest duration; and these observations being already corrected for the thermometer; a mean is taken from the whole as the true rate of acceleration of the pendulum on mean time in twenty-four hours.

T A B L E

1773, in Latitude  $79^{\circ} 44' N$ .

| 9<br>The loss by<br>a watch, ac-<br>cording to its<br>rate of going,<br>determined<br>by the Sun's<br>altitudes. | 10<br>Time gained by<br>the Pendulum on<br>the Mean Time,<br>allowing for the<br>Thermometer,<br>and Rate of the<br>Watch's losing. | 11<br>Ratio of<br>Acceleration<br>per<br>Hour. | 12<br>Ratio of accelera-<br>tion of the Pendu-<br>lum on the Mean<br>Time in Twenty<br>four Hours. |
|--|---|--|--|
| "  | "   | "  |  |
| 2 0,99   | 3,75  | 3,75   |  |
| 1,47   | 4,78  | 3,19   |  |
| 4 2,31   | 9,65  | 4,11   |  |
| 4 5,63   | 19,12   | 3,41   |  |
| 6,14   | 21,95   | 3,52   |  |
| 8,04   | 27,20   | 3,34   |  |
| 10,86  | 37,44   | 3,41   |  |
| 14,79  | 41,04   | 2,73   | "  |
| 22 2,71  | 69,04   | 3,00   | . . 72,07  |
| 22 2,73  | 67,91   | 2,95   | . . 70,79  |
| 23 3,55  | 72,85   | 3,05   | . . 73,24  |
| 23 3,72  | 71,78   | 2,99   | . . 71,71  |
| 24 4,59  | 76,66   | 3,08   | . . 73,98  |
| 24 4,43  | 78,08   | 3,07   | . . 73,86  |
| 25 5,49  | 146,81  | 3,00   | . . 73,57  |
| 25 3,20  | 200,63  | 3,13   | . . 75,23  |
|  |   |  | Mean 73,06   |
|  |   |  | Which gives the<br>Acceleration of<br>the Pendulum on<br>true Time from<br>the change of lat.      |

From

37

From the result of this table, the time gained by the pendulum in twenty-four hours of mean time, after deducting the acceleration on account of the contraction of its rod by the cold, is seventy-three seconds, and six hundredths of a second ; which is one second, and two hundredths of a second more than by the result of the observations of the 16th and 17th of July. But although the rate of going of the watch from the 15th to the 18th days of August, was ascertained by a mean of fifty-five altitudes of the sun, I am inclined to give the preference to the observations of July, where the exact period of twenty-four hours was determined by a revolution of the sun, observed with a telescope whose magnifying power was sixty. And notwithstanding that the height of the thermometer during the time of observation in August was remarkably uniform, and that the watch was found by the comparisons with the pendulum to have lost during the whole time as uniformly as could reasonably be expected ; yet a small irregularity in its rate of going near the beginning or end of the observation, might occasion the difference of this result from the former.

As the time corrected by the mean of six altitudes of the sun taken on the 16th and 17th July, differed only one second and a half from that observed by the revolution of the sun, there is reason to believe that the period of three days, determined

pendulum had gained *one whole minute*, together with the fifteen seconds determined by the pendulum and the revolution of the sun: and although it appears by the eleventh column of the foregoing table that the watch did not lose uniformly at the rate of four seconds in twenty-four hours, yet its mean rate leaves as little doubt with regard to the *whole minute* gained by the pendulum, as if its going had been perfectly uniform during the whole time. For, if from the sum of all the periods in the second column, and of all the accelerations in the tenth, a mean rate be taken, it makes the acceleration of the pendulum on the watch to be  $80''$   $79$  in twenty-four hours, which differs from the acceleration observed by the revolution of the sun only  $5''$   $75$ ; and from the rate of going of the watch, determined by the revolution of the sun, only  $1''$   $79$ : hence there can be no possible room to suppose an error of a whole minute.

Although the period of twenty-four hours, and the rate of going of the watch for that time, are very accurately determined by the revolution of the sun; it may not be improper here to take notice, that from a mean of six altitudes of the sun, taken by a very good astronomical quadrant of eighteen inches radius, the watch was computed to have lost  $5''\frac{1}{2}$ , in twenty-four hours, which differs from the rate given by the revolution of the sun only  $1''\frac{1}{2}$ ; this may serve to shew how far the mean of a great number of observations by the same

same observer and instrument may be relied on, when there is no other observation to check or corroborate.

It may also be proper here to mention, that the time by the watch was not observed at the instant that the sun had returned to the vertical wire, and at which the pendulum was observed to show  $4\frac{1}{2}$  seconds, my attention being wholly engaged in observing the pendulum. The watch was found to have lost  $77\frac{1}{4}$  by the pendulum, in twenty-three hours, twenty-six minutes, forty-five seconds and a half. An allowance according to the rate for  $34' 4''$  (the supplement of the 2d observation by the watch to the time of the sun's passage when the pendulum showed  $4\frac{1}{2}$ ), amounts to  $1:2$ .

From whence it follows, that the Watch time of the sun touching the East side of the vertical wire is five hours, twenty minutes, thirteen seconds and a half, by the watch, which had therefore lost four seconds in twenty-four hours.

As the comparison of the watch and the pendulum in this case affords is not from actual observation, *on the spot*, but supposes that the watch had kept for thirty-four minutes to the same rate of going as which it had been observed to run for nearly twenty-four hours immediately preceding. The time by the watch *now found* is inserted in the table of observations without regard to the magnitude, that every period may have an equal

runity of judging how far it ought to be admitted. Upon the whole it appears, that by the revolution of the sun, corrected for the oblique direction in which it passed the vertical wire in the telescope; the change of declination and the equation from the time of its West limb touching the wire on the 16th, to the time of its touching the same wire on the 17th of July, that the pendulum gained seventy-five seconds in twenty-four hours. But as the mean height of the thermometer for the time of this experiment was  $90\frac{1}{2}$  lower than  $60^{\circ}$ , the height at which it was at London when the pendulum was compared with the clock, the pendulum ought on this account, according to Mr. Smeaton's experiments, to have been contracted  $\frac{1\frac{1}{2}}{10000}$  of an inch, and to have gained on that account  $2,72$ ; so that the acceleration of the pendulum arising only from the difference between the latitude of London and  $79^{\circ} 50' N$ , is  $72'', 28$ .

The pendulum was continued in motion, and the comparisons between it and the watch made as before, with intention to take a second revolution of the sun: but at eleven o'clock next morning, the wind being fair, and the weather cloudy so as to afford no prospect of seeing the sun in the afternoon, the instruments were taken on board, and the ships sailed immediately.

August

August the fourteenth, we landed the Pendulum, Equatorial Instrument, and astronomical Quadrant on Smeerenberg Point, latitude  $79^{\circ} 44'$  N; and set up the pendulum in every respect as formerly described. The equatorial and quadrant were also set up, and prepared for observation.

The pendulum was set a going when it was exactly  $6^h 0' 0''$  P. M. by my watch, from which time it was frequently compared with the watch, till  $5^h 50'$  A. M. the 15th; when the pendulum stopped. It was again set a going with the additional weight which had formerly been used, when the watch was exactly  $6^h 00' 00''$ , and continued going from that time till after five in the morning of the 18th, in which time the thermometer was observed, and the watch and pendulum compared, as in the following table: many altitudes of the sun were taken with the quadrant, on the 15th A. M. but without any further opportunity till the 18th A. M. when they were repeated to ascertain the rate of the watch's losing.



URSUS *Maritimus*. Linn. *Syst. Nat.* 70. 1.

Polar Bear. Penn. *Syn. Quadr.* p. 192. T.  
20. F. 1.

Found in great numbers on the main land of Spitzbergen; as also on the islands and ice fields adjacent. We killed several with our musquets, and the seamen ate of their flesh, though exceeding coarse. This animal is much larger than the black bear; the dimensions of one were as follows:

|  | Feet. Inches. |   |
|--|---------------|---|
| Length from the snout to the tail,                             | 7             | 1 |
| Length from the snout to the shoulder-bone,                    | 2             | 3 |
| Height at the shoulder, - -                                    | 4             | 3 |
| Circumference near the fore legs, -                            | 7             | 0 |
| Circumference of the neck close to the ear,                    | 2             | 1 |
| Breadth of the fore paw, -                                     | 0             | 7 |
| Weight of the carcass without head, skin<br>or entrails, - - - | 610 lb.       |   |

CERVUS *Tarandus*. Linn. *Syst. Nat.* 93. 4.

Rein Deer. Penn. *Syn. Quadr.* p. 46. T. 8.  
F. 1.

Found every where on Spitzbergen.

We ate the flesh of one which we killed, and found it excellent venison.

BALAENA *Mysticetus*. Linn. *Syst. Nat.* 105. 1.

Common Whale. Penn. *Brit. Zool.* p. 85.

This

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This species, which is sought after by the fishermen in preference to all other whales, is found generally near the ice. We saw but few of them during our stay.

*BALAENA Physalas. Linn. Syst. Nat. 106. 2.*

Fin Fish. *Penn. Brit. Zool. p. 41.*

Found in the ocean near Spitsbergen.

## A V E S.

*ANAS mollissima. Linn. Syst. Nat. 198. 15.*

Eider Duck. *Penn. Brit. Zool, p. 454.*

Found on the coast of Spitsbergen.

*ALCA arctica. Linn. Syst. Nat. 211. 4.*

The Puffin. *Penn. Brit. Zool. p. 405.*

Found on the coast of Spitsbergen.

*ALCA Alle. Linn. Syst. Nat. 211. 5.*

Found on the coast of Spitsbergen in great abundance.

*PROCELLARIA glacialis. Linn. Syst. Nat. 213. 3.*

The Fulmar. *Penn. Brit. Zool. p. 431.*

Found on the coast of Spitsbergen.

*COLYMBUS Grylle. Linn. Syst. Nat. 220. 1.*

Found on the coast of Spitsbergen.

COLYMBUS

*COLYMBUS Troile. Linn. Syst. Nat. 220. 2.*

Found on the coast of Spitsbergen.

*COLYMBUS glacialis. Linn. Syst. Nat. 221. 5.*

The great Northern Diver. *Penn. Brit.*

*Zool. p. 413.*

Found on the coast of Spitsbergen.

*LARUS Rissa. Linn. Syst. Nat. 224. 1.*

Found on the coast of Spitsbergen.

*LARUS Parasiticus. Linn. Syst. Nat. 226. 10.*

The Arctic Gull. *Penn. Brit. Zool. p. 420.*

Found on the coast of Spitsbergen.

*LARUS Eburneus, niveus, immaculatus, pedibus  
plumbeo-cinereis.*

Found on the coast of Spitsbergen.

This beautiful bird is not described by Linnæus, nor, I believe, by any other author; it is nearly related indeed to the Rathsker, described by Marten in his voyage to Spitsbergen, (See page 77 of the English translation) but, unless that author is much mistaken in his description, differs essentially from it. Its place in the *Systema Naturæ* seems to be next after the *Larus naevius*, where the specific difference given above, which will distinguish it from all the species described by Linnæus, may be inserted.

DESCRIPTION.

## DESCRIPTION.

Tota avis (quoad pennas) nivea, immaculata.

Rostrum plumbeum.

Orbitæ oculorum croceæ.

Pedes cinereo-plumbei. Ungues nigri.

Digitus Posticus articulatus, unguiculatus.

Alæ cauda longiores.

Cauda æqualis, pedibus longior.

Longitudo totius avis, ab apice rostri ad

|              |   |   |           |
|--------------|---|---|-----------|
| finem caudæ, | - | - | Uncias 16 |
|--------------|---|---|-----------|

|   |  |  |    |
|---|--|--|----|
| Longitudo inter apices alarum expansarum, |  |  | 37 |
|---|--|--|----|

|              |   |   |   |
|--------------|---|---|---|
| ———— Rostri, | - | - | 2 |
|--------------|---|---|---|

STERNA *Hirundo*. Linn. *Syst. Nat.* 227. 2.

The greater Tern. Penn. Brit. Zool. p. 428.

Found on the coast of Spitsbergen.

EMBERIZA *nivalis*. Linn. *Syst. Nat.* 308. 1.

The greater Brambling. Penn. Brit.

Zool. 321.

Found not only on the land of Spitsbergen, but also upon the ice adjacent to it, in large flocks: what its food can be is difficult to determine; to all appearance

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pearance it is a granivorous bird, and the only one of that kind found in these climates, but how that one can procure food in a country which produces so few vegetables, is not easy to guess.

A M P H I B I A.

*CYCLOPTERUS Liparis. Linn. Syst. Nat. 414. 3.*

Sea Snail. *Penn. Brit. Zool. III. p. 105.*

Two only of these were taken in a trawl near Seven Island Bay.

P I S C E S.

*GADUS carbonarius. Linn. Syst. Nat. 438. 9.*

The Coal Fish. *Penn. Brit. Zool. III. p. 152.*

Though we trawled several times on the North side of Spitsbergen, and the seamen frequently tried their hooks and lines, yet nothing was taken except a few individuals of this and the foregoing species.

I N S E C T A.

*CANCER Squilla. Linn. Syst. Nat. 1051. 66.*

The Prawn. *Merr. Pin. 192.*

Found

Found in the stomach of a seal, caught near the coast of Spitzbergen.

*CANCES Boreas*, macrourus, thorace carinato aculeato, manibus lævibus, pollice subulato incurvo.

This singular species of Crab, which has not before been described, was found with the former in the stomach of a Seal; its place in the *Systema Naturæ* seems to be next after *Cancer Norwegicus*.

#### DESCRIPTION.

*Thorax* ovatus, tricarinatus: *Carinæ laterales* tuberculosæ, antice spina acuta terminatæ; *Carina dorsalis* spinis tribus vel quatuor validis armata; antice producta in rostrum porrectum, acutum, breve, Thorace quintuplo brevius; præter spinas carinarum, anguli laterales thoracis antice in spinas terminantur.

*Antennæ* duæ, thorace fere triplo breviores, bifidæ: *Ramulus superior* crassiusculus, filiformis, obtusus; *Inferior* gracilis, subulatus.

*Palpi* duo, duplicati; *Ramus superior* foliatus, seu explanatus in *laminam* ovalem, obtusam, longitudine antennarum, intus et antice villis ciliatam; *Ramus interior* antenniformis, subulatus, multiaarticulatus, antennis triplo longior.

*Parastatides*

*Parastatides* decem, anteriores parvi; postremi magni, pediformes articulo ultimo explanato in laminam ovali-oblongam.

*Pedes* decem, duo primores cheliferi, carpis incrassatis, reliqui simplices; pares secundi et tertii filiformes, graciles; quarti et quinti crassiusculi.

*Cauda* thorace longior, sexarticulata; articulis quinque anterioribus carinatis, carinis spina antrorsum vergente armatis; articulus sextus supra bicarinatus, muticus, terminatus *foliolis* quinque, articulis caudæ longioribus; intermedio lanceolato, acuto, porrecto, crasso, supra planiusculo, quadricarinato carinis interioribus obsoletis, subtus concavo; lateralibus ovali-oblongis, obtusis.

*Neusteri* decem (nulli sub articulo ultimo) duplicati: *Foliolis* lanceolatis, ciliatis.

*Obs.* Specimina magnitudine variant, alia triuncialia, alia septem uncias longa.

**CANCER** *Ampulla*, macrourus, articularis, corpore ovali, pedibus quatuordecim simplicibus, laminis femorum postici paris ovato-subrotundis.

This singular animal was also taken out of the stomach of the same seal in which the two former were found. Its place in the *Systema Naturæ* is next to *Cancer Pulex*.

DESCRIPTION.

## DESCRIPTION.

Insectum ex ovali-oblongum, glabrum, punctulatum, articulis quatuordecim compositum, quorum primus capitis est, septem thoracem mentiuntur, et sex caudam tegunt.

*Capitis* clypeus antice inter antennis in processum conicum, acutum descendit.

*Antennæ* quatuor, subulatæ, articulatæ, simplices, corpore decuplo breviores.

*Pedes* quatuordecim, simplices, unguiculati; *femora* postremi paris postice acuta, lamina dimidiato-subrotunda, integra, magna, quatuor lineas longa.

*Cauda* foliata, foliolo unico brevi bifido: *Laciniae* lanceolatæ, acutæ.

*Neusteri* duodecim, duplicati, subulati, pilis longis ciliati, posteriores retrorsum porrecti.

*Obs.* Specimina magnitudine variant, uncialia et biuncialia erant.

*CANCER nugax*, macrourus, articularis, pedibus quatuordecim simplicibus, laminis femorum sex posteriorum dilatatis subrotundo-cordatis.

This animal, which has not before been described, should be inserted in the *Systema Naturæ* near *Cancer Pulex*; it was taken in the trawl near Moffen Island.



## DESCRIPTION.

Insectum oblongum, compressum, dorso rotundatum, glabrum, sesquiunciale, articulis quatuordecim compositum, quorum primus capitis est, septem thoracem mentiuntur, et sex caudam efficiunt.

*Capitis Clypeus* sinu obtuso antice pro antennis emarginatus.

*Antennæ* quatuor, subulatæ, multiarticulatæ; *superiores* corpore sextuplo breviores, bifidæ: articulo baseos communi, magno; *Ramulus* interior exteriori duplo brevior.

*Inferiores* simplices, superioribus duplo longiores.

*Pedes* quatuordecim, simplices, unguiculati, unguibus parum incurvis. *Femora* sex posteriora postice aucta.

*Lamina* foliacea, subrotundo-cordata, dimidiata, margine integra, magna, (tres lineas longa.)

*Cauda* apice foliata. *Foliolis* duobus, oblongis, obtusis, parvis.

*Neusteri* duodecim, duplicati, lineari-lanceolati, posteriores retrorsum porrecti, ut facile pro appendicibus caudæ sumantur.

CANCER *Pulex*. Linn. *Syst. Nat.* p. 1055. 81.

Taken up in the trawl along with the former.

## V E R M E S.

SIPUNCULUS *Lendix*, corpore nudo cylindraceo, apertura subterminali.

Found adhering, by its small snout, to the inside of the intestines of an Eider Duck. Mr. Hunter, who at my request dissected it, informed me that he had seen the same species of animal adhering to the intestines of whales.

## D E S C R I P T I O N.

*Corpus* croceum, subcylindraceum, tres lineas longum, crassitie pennæ passerinæ, utraque extremitate parum attenuatum, apice terminatum in *Rostrum* angustum corpore quintuplo brevius, quo tunicis internis intestinorum sese affigit; prope alteram extremitatem *Apertura* simplex, pro lubitu extensibilis.

ASCIDIA *gelatinosa*. Linn. *Syst. Nat.* 1087. 2.

Taken up in the trawl, on the North side of Spitzbergen.

*ASCIDIA rustica. Linn. Syst. Nat. 1087. 5.*

Taken up likewise in the trawl, on the North side of Spitsbergen.

*LERNEA branchialis. Linn. Syst. Nat. 1092. 1.*

Found in the gills of the Sea snail mentioned before.

*CLIO belicina nuda corpore spirali.*

*Marten's Spitsbergen Englisb, p. 141. t. Q.  
fig. c. Snail slime fish.*

Found in innumerable quantities throughout the Arctic seas.

#### D E S C R I P T I O N.

*Corpus* magnitudine pisi, in spiram ad instar helicis involutum.

*Alæ* ovatae, obtusæ, expansæ, corpore majores.

*CLIO limacina nuda, corpore obconico.*

The Sea May Fly. *Marten's Spitsbergen Englisb, p. 169. Tab. P. f. 5.*

This little animal is found where the last is, in equal abundance, peopling as it were this almost  
unin-

uninhabited ocean. Marten says that they are the chief food of the whale-bone whale; and our fishermen, who call them by the name of whale food, are of the same opinion.

*MEDUSA capillata. Linn. Syst. Nat. 1097. 6.*

Sea Blubber.

Taken up on the passage home, about the latitude 65°.

*ASTERIAS papposa. Linn. Syst. Nat. 1098. 2.*

Taken up on the North side of Spitsbergen.

*ASTERIAS rubens. Linn. Syst. Nat. 1099. 3.*

Sea Star.

Also taken up in the trawl on the North side of Spitsbergen.

*ASTERIAS Ophiura. Linn. Syst. Nat. 1100. 11.*

We likewise took this up in the trawl, on the North side of Spitsbergen.

*ASTERIAS pectinata. Linn. Syst. Nat. 1101. 14.*

This, as well as all the rest of this genus, was taken up in the trawl on the North side of Spitsbergen.

*CHITON ruber. Linn. Syst. Nat. 1107. 7.*

Coat of Mail Shell.

Taken in the trawl, on the North side of Spitzbergen.

*LEPAS Tintinnabulum. Linn. Syst. Nat. 1168. 12.*

Acorn Shell.

Was picked up on the beach of Smeerenberg harbour; but as it is much worn and broken, it is impossible to be certain, whether it is a native of those seas, or has been brought there by accident.

*MYA truncata. Linn. Syst. Nat. 1112. 26.*

Likewise found on the beach in Smeerenberg harbour.

*MYTILUS rugosus. Linn. Syst. Nat. 1156. 249.*

Was found with the former on the beach at Smeerenberg.

*BUCCINUM carinatum*, testa oblongo-conica transversim striata; anfractibus superioribus oblique obtuseque multangulis; inferioribus unicarinatis.

Found on the beach at Smeerenberg harbour.

TURBO

*TURBO belicinus*, testa umbilicata convexa obtusa : anfractibus quatuor lævibus.

Taken up in the trawl, on the North side of Spitsbergen.

*SERPULA spirorbis*. *Syst. Nat.* 1265. 794.

Found in plenty sticking to the stones and dead shells in Smeerenberg harbour.

*SERPULA triquetra*. *Linn. Syst. Nat.* 1265. 795.

Found with the last adhering to dead shells.

*SABELLA frustulosa*, testa solitaria libera simplici curvata : fragmentis conchaceis sabulosisque.

Taken up in the trawl on the North side of Spitsbergen.

# DESCRIPTION.

Vagina spithamea vel longior, crassitie pennæ anserinæ, undique testæ *fragmentis conchaceis* sæpe magnitudine unguis, et sabulis magnitudine feminum cannabis.

*MILLEPORA polymorpha*. *Linn. Syst. Nat.* 1285. 53.

Varietas rubra.

Found thrown up on the beach at Smeerenberg harbour.

*CELLEPORA pumicosa*. Linn. Syst. Nat. 1286. 56.  
Found on the beach at Smeerenberg.

*SYNOICUM turgens*.

Taken up in the trawl, on the North side of Spitsbergen.

This animal is quite new to the Natural Historians, and so different from the Zoophytes which have been hitherto described, that it may be considered as a distinct genus, whose characters are the following:

*Animalia* nonnulla, ex apice singuli stirpis sese aperientia.

*Stirpes* plures, radicatæ, carnosæ-stuposæ, e basi communi erectæ, cylindræ, apice regulariter pro animalibus pertusæ.

It should be inserted next to the Alcyonium, with which it in some particulars agrees, but differs from it materially in having the openings for the animals only at the top, and the animals themselves not exerted like polypes (Hydra) which is the case in the Alcyonium.

D E S C R I P T I O N.

*Stirpes* plures, radicatæ, carnosæ-stuposæ, digitiformes, cylindræ, superne paulo crassiores, obtusæ, magnitudine digiti infantis, suberectæ, apice orificiis nonnullis perforatæ, inferne dilatatæ sue explanatæ

explanatæ in basin communem lapidibus adhærentem.

*Orificia* sex ad novem, ordine circulari plerumque disposita; sub singulo orificio cavitas longitudinalis, forsitan singulo animali propria, in qua

1<sup>mo</sup> *Faux* angusta, brevis.

2<sup>do</sup> *Intestinum* instar stomachi dilatatum, oblongo-ovatum, inferne *foraminibus* duobus pertusum; inter illa foramina aliud descendit intestinum, valde angustum, filiforme, arcum brevem formans.

*Cavitas*, quæ per totam stirpem longitudinaliter pro singulo animali deorsum tendit, superne ab intestinis vix distincta, infra illa autem cylindrum exhibet granulis parvis (forsitan ovulis) repletam.

*FLUSTRA pilosa. Linn. Syst. Nat. 1301. 3.*

Found adhering to stones in Smeerenberg harbour.

*FLUSTRA membranacea. Linn. Syst. Nat. 1301. 5.*

Found with the last mentioned species.

## P L A N T Æ.

*AGROSTIS algida* panicula mutica contracta, calycibus brevissimis inæqualibus.

This



This small grass, which has not before been known to botanists, may be inserted among the species of *Agrostis* next to the *minima*.

### D E S C R I P T I O N .

Gramen in cæspitibus nascens.

*Radix* fibrosa, perennis.

*Folia* plurima radicalia, paucissima caulina, glabra, latiuscula, longitudine culmi, patula, basi dilatata in vaginas laxas.

*Culmi* adscendentes, glabri, fœsquiunciales.

*Panicula* lineari-oblonga, contracta, stricta, multiflora.

*Calycis Glumæ* membranaceæ, albidæ, glabræ, muticæ, inæquales: *exterior* minutissima, ovata, obtusa; *interior* oblonga, acuta, corolla quintuplo brevior.

*Corollæ Glumæ* oblongæ, acutæ, carinatae, muticæ, glabræ, femilineares: *exterior* paulo longior.

*Stamina* tria.

*Stigmata* duo.

*Semen* unicum, oblongum, utrinque acuminatum, a corolla liberum.

*TILLÆA aquatica*. Linn. Spec. Plant. 186. 2.

*JUNCUS campestris*. Linn. Spec. Plant. 468. 17.

SAXIFRAGA

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SAXIFRAGA *oppositifolia*. Linn. *Spec. Plant.* 575. 18.

SAXIFRAGA *cernua*. Linn. *Spec. Plant.* 577. 26.

SAXIFRAGA *rivularis*. Linn. *Spec. Plant.* 577. 28.

SAXIFRAGA *cæspitosa*. Linn. *Spec. Plant.* 578. 34.

CERASTIUM *alpinum*. Linn. *Spec. Plant.* 628. 8.

RANUNCULUS *fulp bureus*, calycibus hirsutis, caule subifloro, petalis rotundatis, integerrimis, foliis inferioribus sublobatis, supremis multipartitis.

Ranunculus quartus. Mart. Spitz. Engl. p. 58.  
T. T. F. d.

Obf. Primo intuitu Ranunculo glaciali fimillimus, differt autem, quod Petala rotundata, integerrima, intente lutea, fulgida; et Folia minus subdivifa; *superiora* fiffa, laciniis oblongo-lanceolatis integerrimis *inferiora caulina* lata, plana, leviter triloba vel quadriloba.

This new plant should be inserted next to *Ranunculus glacialis*.

COCHLEARIA *Danica*. Linn. *Spec. Plant.* 903. 3.

COCHLEARIA *Groenlandica*. Linn. *Spec. Plant.* 904. 4.

SALIX *herbacea*. Linn. *Spec. Plant.* 1445. 16.

POLYTRICHUM *commune*. Linn. *Spec. Plant.* 1573. 1.

BRYUM

*BRYUM Hypnoides. Linn. Spec. Plant. 1584. 21.*

Besides these, there were two other kinds of *Bryum*, the species of which could not be determined, for want of the fructification; the one resembled *Bryum trichoides læte virens*, &c. *Dill. Musc. 391, t. 50, f. 61*; and the other *Bryum hypnoides pendulum*, *Dill. Musc. 394, t. 50, F. 64, C.*

*HYPNUM aduncum. Linn. Spec. Plant. 1592. 23.*

*JUNGERMANNIA julacea. Linn. Spec. Plant. 1601. 20.*

Another species of *Jungermannia* was also found, but without fructification; it is not much unlike *Lichenastrum ramosius foliis trifidis*. *Dill. Musc. 489, t. 70, f. 15.*

*LICHEN ericetorum. Linn. Spec. Plant. 1608. 12.*

*LICHEN Islandicus. Linn. Spec. Plant. 1611. 29.*

*LICHEN nivalis. Linn. Spec. Plant. 1612. 30.*

*LICHEN caninus. Linn. Spec. Plant. 1616. 48.*

*LICHEN polyrrhizos. Linn. Spec. Plant. 1618. 57.*

*LICHEN pyxidatus. Linn. Spec. Plant. 1619. 60.*

*LICHEN cornutus. Linn. Spec. Plant. 1620. 64.*

LICHEN

LICHEN *rangiferinus*. *Linn. Spec. Plant.* 1620. 66.

LICHEN *globiferus*. *Linn. Mant.* 133.

LICHEN *pascualis*. *Linn. Spec. Plant.* 1621. 69.

LICHEN *calybeiformis*. *Linn. Spec. Plant* 1623. 77.

ACCOUNT of DOCTOR IRVING'S Method of obtaining  
fresh Water from the Sea by Distillation.

**A**S the method of rendering salt water fresh, by distillation, introduced by Doctor Irving into the Royal Navy in the year 1770, and practised in this voyage, is an object of the highest importance to all navigators, and has not hitherto been generally known, I have added the following very full account of its principles, apparatus, and advantages, with which I was favoured by Doctor Irving himself.

“PREVIOUS to an account of this method of rendering sea water fresh by distillation, it may not be improper to give a short detail of the experiments which have been formerly made by others on this subject, pointing out at the same time the several disadvantages attending their processes, and the general causes which obstructed the desired success.

“Without entering into an account of the earlier experiments, it will be sufficient to take a view of such as have been prosecuted with most attention, for the last forty years.

“The first of these was the process of Mr. Appleby, published by order of the Lords of the Admiralty,

" Admiralty, in the Gazette of June 22d, 1734.  
 " By the account of that process it appears, that  
 " Mr. Appleby mixed with the sea water to be dis-  
 " tilled, a considerable quantity of the *Lapis In-*  
 " *fernalis* and calcined bones. The highly unpa-  
 " latable taste of the water, however, exclusive of the  
 " extreme difficulty, if not impossibility, of reduc-  
 " ing the process into practice, prevented the fur-  
 " ther prosecution of this method.

" Another process for procuring fresh water at  
 " sea, was afterwards published by Doctor Butler.  
 " Instead of the *Lapis Infernalis* and calcined bones,  
 " he proposed the use of soap leys; but though the  
 " ingredients were somewhat varied, the water  
 " was liable to the same objections as in the preced-  
 " ing experiment. Doctor Stephen Hales used  
 " powdered chalk; and introduced ventilation, by  
 " blowing showers of air up through the distilling  
 " water, by means of a double pair of bellows. It  
 " was found by this method, that the quantity of  
 " fresh water obtained in a given time, was some-  
 " what greater than what had been procured by  
 " the process of Mr. Appleby. This invention,  
 " however, was subject to several disadvantages.  
 " The air box which lay on the bottom of the still,  
 " as well as the chalk, much obstructed the action  
 " of the fire upon the water, at the same time that  
 " the boiling heat of the latter was diminished by  
 " the ventilation: so that more than double the  
 " usual

“usual quantity of fuel was necessary to produce the  
 “same effect. Besides this method by no means  
 “improved the taste of the water.

“The next who attempted any improvement  
 “was the learned Doctor Lind, of Portsmouth.  
 “He distilled sea water without the addition of  
 “any ingredients; but as the experiment he made  
 “was performed in a vessel containing only two  
 “quarts, with a glass receiver, in his study, no-  
 “thing conclusive can be drawn from it for the use  
 “of shipping. Indeed experiments of the like  
 “kind had been made by the chemists in their la-  
 “boratories, for at least a century before.

“In the year 1765, Mr. Hoffman introduced  
 “a Still of a new construction, with a *secret ingre-*  
 “*dient*; but the large space which this machine  
 “occupied, being seven feet five inches by five  
 “feet eight inches, and, with its apparatus, six  
 “feet seven inches high, made it extremely incon-  
 “venient: at the same time that, on account of  
 “its shallow form, the use of it was impracticable  
 “during any considerable motion of the ship. The  
 “water obtained, likewise, possessed all the disad-  
 “vantages common to the preceding methods.

“About the same time experiments were made  
 “with a still of the common construction, and Mr.  
 “Dove's *ingredient*. This method was attended  
 “with

“ with no advantage over any that had been formerly used; the distilled water was most unpalatable; and the enormous size of the apparatus, which occupied a space of thirteen feet seven inches by six feet one inch, and six feet five inches in height, rendered it impracticable on board ships. An experiment was immediately afterwards made with the same still without any ingredient; the result, however, was uniformly a most unpalatable taste of the water.

“ About this period, also, M. Poissonnier of Paris introduced into the French marine a still, three feet six inches long, two feet wide, and eighteen inches deep. A portion of the chimney passed through the upper part of the still, much in the same manner as that of Mr. Hoffman: these gentlemen supposed that by this means they should save fuel. The mouth of M. Poissonnier's still was thirteen inches wide, on which he placed a tin plate, pierced like a cullender, with thirty-seven holes of six lines diameter each; to these were fixed tin pipes, of the same bore and seven inches long, terminating within the still-head. The intention of this contrivance is to prevent any of the water in the still from passing over into the worm, while the ship is in considerable motion.



“ In every other respect M. Poissonnier employs  
 “ a still-head, worm-pipe, and worm-tub, with  
 “ all its usual apparatus; and he directs six ounces  
 “ of *fossil alkali* to be mixed with the sea water at  
 “ each distillation, to prevent the acid of the Mag-  
 “ nesia salt from rising with the vapour, when salt  
 “ begins to form on the bottom of the still. It is  
 “ probable that in M. Poissonnier’s still, which was  
 “ even more shallow in its form than Mr. Hoff-  
 “ man’s, some of the water might be thrown up  
 “ toward the worm; in which case the pierced  
 “ plate with pipes might be of some service in  
 “ breaking the direction of the water. But by  
 “ Doctor Irving’s tube this inconvenience is entirely  
 “ prevented, as experience fully evinces, viz. in a  
 “ voyage to Falkland’s Islands, where it has been  
 “ used in distillation every day; in several voyages  
 “ to the East Indies; and in this voyage, as is men-  
 “ tioned in the Journal.

“ M. Poissonnier, in correcting this error in the  
 “ construction of his still, has introduced another  
 “ of the most capital nature in distillation. For  
 “ by means of the pipe-cullender, the vapour will  
 “ meet with the greatest resistance to its ascent,  
 “ which will retard the progress of distillation in a  
 “ very high degree, and increase the *Empyreuma*.

“ From all the experiments abovementioned, it  
 “ is evident, that no method had hitherto been  
 “ invented of making sea-water fresh, which was  
 “ not attended with such inconveniences as rendered

“ the

“ the several processes of scarce any utility. The defects of the various methods above enumerated, may be reduced to the following heads:

“ 1. The small quantity of water produced by the ordinary methods of distillation with a still-head, and worm, could never be adequate to the purposes of shipping, though the apparatus should be kept in constant use; and at the same time, this mode of distillation required a quantity of fuel, which would occupy greater space than might be sufficient for the stowage of water.

“ 2. A *Still-burnt* taste, which always accompanies this method of distillation, and renders the water extremely unpalatable, exciting heat and thirst, if drank when recently distilled.

“ 3. A total ignorance with respect to the proper time of stopping the distillation, whereby salt was permitted to form on the bottom of the boiler; which burning, and corroding the copper, decomposed the selenitic and magnesia salts, causing their acids to ascend with the vapour, and act on the still-head and worm pipe, impregnating the water with metallic salts of the most pernicious quality.

“ 4. The space occupied by the still, still-head, and worm-tub, renders the use of them in most cases totally impracticable on board ships. Add to this, their wearing out so fast on account of the

“ causes above mentioned, the great expence of  
 “ the apparatus, with the hazard of the still-head  
 “ being blown off, and the inconveniences thence  
 “ arising.

“ 5. The use of ingredients, which though  
 “ omitted in some experiments in small, were ne-  
 “ vertheless erroneously considered as essential to the  
 “ making sea-water sweet and palatable by distillation.

“ 6. The inconvenience of a cumbersome appa-  
 “ ratus, calculated only to be eventually useful in  
 “ unexpected distress for water, but constantly  
 “ occupying a great deal of room in a ship, too  
 “ necessary for the ordinary purpose to be spared  
 “ for that object.

“ Having specified the principal defects of the  
 “ several methods hitherto proposed for making sea  
 “ water fresh, it will be proper before stating the  
 “ advantages of Doctor Irving's method, to con-  
 “ sider briefly the principles of distillation in gene-  
 “ ral, and the chemical analysis of sea water.

“ Water, in an exhausted receiver, rises in va-  
 “ pour more copiously at  $180^{\circ}$  of Fahrenheit's  
 “ thermometer, than in the open air at  $212^{\circ}$ ,  
 “ which may be considered as its boiling point.

“ It therefore follows, that any compression upon  
 “ boiling fluid checks the vapour in rising, and  
 “ consequently diminishes the quantity of water  
 “ obtained. This is clearly exemplified in the  
 “ steam-

“ steam-engine, where the consumption of water  
 “ in the boiler is very inconsiderable, in compa-  
 “ rison to what would happen if the compression  
 “ arising from the throat-pipe and valve of that  
 “ machine was taken off, and the pressure of the  
 “ atmosphere only admitted. But by the restraint  
 “ of that valve, the vapour becomes hotter, and  
 “ increases in rarity and elasticity; qualities essen-  
 “ tial to the purposes of the engine, although the  
 “ reverse of those which ought to take place in  
 “ common distillation. For the columns of vapour  
 “ should be removed from the boiling fluid as fast as  
 “ they ascend, without suffering any other resistance  
 “ than that of the atmosphere, which, in the or-  
 “ dinary business of distillation, cannot be prevented.

“ The impropriety of the common process of  
 “ distillation, will appear evident by comparing it  
 “ with the above principles and facts.

“ In the common method of distillation, the  
 “ whole column of vapour from a still of whatever  
 “ size, after ascending to the still-head, must not  
 “ only find its passage through a pipe of scarce an  
 “ inch and half diameter; but descend contrary to  
 “ its specific gravity through air which is fifteen  
 “ times its weight, in spiral convolutions: a course  
 “ so extremely ill adapted to the progress of an  
 “ elastic vapour, that frequently the still-head is  
 “ blown off with incredible violence, owing to the

“ increased heat and elasticity of the vapour confined  
 “ by this construction. In the mean time, the ex-  
 “ ternal surface of the pipe communicates heat to  
 “ the water in contact with it, which, instead of  
 “ being entirely carried off, mixes with the sur-  
 “ rounding fluid, and heats the whole, rendering  
 “ it unfit for condensing the vapour within; espe-  
 “ cially when it is considered that the substance of  
 “ the pipe is at least a quarter of an inch thick.

“ From what has been said, it is plain, that the  
 “ quantity of distilled water will be lessened in pro-  
 “ portion to the resistance made to the ascent of the  
 “ vapour, while the difficulty of condensation will  
 “ be greatly augmented, in consequence of the in-  
 “ creased heat and elasticity of the vapour. But  
 “ these disadvantages, however great, respecting  
 “ the mode of distillation, give rise to another evil  
 “ of a still more important nature, as affecting the  
 “ distilled fluid with a noxious *burnt taste* or *empy-  
 “ reuma*; occasioned by the vapour, highly heated,  
 “ passing over so much surface of metal, viz. the  
 “ still-head, crane-neck, and a pipe of six or seven  
 “ feet in length, before it reaches the water in the  
 “ worm tub.

“ Having discussed the subject of distillation, we  
 “ come now to treat of the chemical analysis of sea  
 “ water.

“ Sea-water,

“ Sea-water contains chiefly a neutral salt, composed of fossil alkali and marine acid. It likewise contains a salt which has magnesia for its basis, and the same acid. These two salts are blended together in our common salt in England, which is prepared by quick boiling down sea water. But when the process is carried on by the sun, or a slow heat, they may be collected separately; that which has the fossil alkali for its basis crystallizing first; and this is of a vastly superior quality for preserving meat, and for the other culinary purposes. The mother liquor now remaining, being evaporated, affords a vitriolic magnesia salt, which in England is manufactured in large quantities, under the name of Epsom salt.

“ Besides these salts, which are objects of trade, sea-water contains a selenitic salt, a little true Glauber's salt, often a little nitre, and always a quantity of gypseous earth suspended by means of fixed air.

“ The specific gravity of sea-water to that of pure distilled water, is at the Nore as 1000 to 1024,6; in the North sea as 1000 to 1028,02.

“ The quantity of salt obtained by boiling sea-water in different latitudes, from  $51^{\circ} 30'$  to  $80^{\circ}, 43$  N. L. is inserted in a table in the former part of this Appendix.

Q 4

“ Sea water,

“ Sea-water, when boiled down to a strong brine,  
“ admits with difficulty the separation of fresh water  
“ from it; the distillation becoming slower as the  
“ strength of the brine increases, so that a greater  
“ quantity of fuel is consumed in procuring a smaller  
“ portion of water, and this likewise of a bad qua-  
“ lity. From this essential circumstance arises the  
“ necessity of letting out the brine by the cock of  
“ the boiler, when the distillation is advanced to a  
“ certain degree; and of adding more sea-water to  
“ continue the process if required.

“ The defects of the several schemes formerly  
“ proposed for rendering sea-water fresh being point-  
“ ed out, the general principles of distillation ex-  
“ plained, and the component parts of sea-water  
“ analytically examined; the advantages of the  
“ method invented by Doctor Irving remain to be  
“ stated, which may be reduced to the following:

“ 1. The abolishing all stills, still heads, worm  
“ pipes, and their tubs, which occupy so much  
“ space as to render them totally incompatible with  
“ the necessary business of the ship; and using in  
“ the room of these, the ship's kettle or boiler, to  
“ the top whereof may occasionally be applied a  
“ simple tube, which can be easily made on board  
“ a vessel at sea, of iron plate, stove funnel, or tin  
“ sheet; so that no situation can prevent a ship from  
“ being completely supplied with the means of  
“ distilling sea-water.

“ 2. In

“ 2. In consequence of the principles of distilla-  
 “ tion being fully ascertained, the contrivance of  
 “ the simplest means of obtaining the greatest quan-  
 “ tity of distilled water, by making the tube suffi-  
 “ ciently large, to receive the whole column  
 “ of vapour ; and placing it nearly in a horizontal  
 “ direction to prevent any compression of the fluid,  
 “ which takes place so much with the common  
 “ worm.

“ 3. The adopting the simplest and most effica-  
 “ cious means of condensing vapour ; for nothing  
 “ more is required in the distillation but keeping the  
 “ surface of the tube always wet ; which is done  
 “ by having some sea-water at hand, and a person  
 “ to dip a mop or swab into this water, and pass it  
 “ along the upper surface of the tube. By this  
 “ operation the vapour contained in the tube will be  
 “ entirely condensed with the greatest rapidity ima-  
 “ ginable ; for by the application of the wet mop  
 “ thin sheets of water are uniformly spread, and  
 “ mechanically pressed upon the surface of the hot  
 “ tube ; which being converted into vapour, make  
 “ way for a succession of fresh sheets ; and thus  
 “ both by the evaporation and close contact of the  
 “ cold water constantly repeated, the heat is carried  
 “ off more effectually than by any other method  
 “ yet known.

“ 4. The carrying on the distillation without any  
 “ addition, a correct chemical analysis of sea wa-  
 “ ter having evinced the futility of mixing ingre-  
 “ dients



“dients with it, either to prevent an acid from  
 “rising with the vapour, or to destroy any bitu-  
 “minous oil supposed to exist in sea water, and to  
 “contaminate the distilled water, giving it that  
 “fiery unpalatable taste inseparable from the former  
 “processes.

“5. The ascertaining the proper quantity of  
 “sea water that ought to be distilled, whereby the  
 “fresh water is prevented from contracting a  
 “noxious impregnation of metallic salts, and the  
 “vessel from being corroded and otherwise damaged  
 “by the salts caking on the bottom of it.

“6. The producing a quantity of sweet and  
 “wholesome water, perfectly agreeable to the taste,  
 “and sufficient for all the purposes of shipping.

“7. The taking advantage of the dressing the  
 “ship's provisions, so as to distil a very considerable  
 “quantity of water from the vapour which would  
 “otherwise be lost, without any addition of fuel.

“To sum up the merits of this method in a few  
 “words:

“The use of a simple tube, of the most easy  
 “construction, applicable to any ship's kettle. The  
 “rejecting all ingredients. Ascertaining the pro-  
 “portion of water to be distilled, with every ad-  
 “vantage of quality, saving of fuel, and preserva-  
 “tion of boilers. The obtaining fresh water,  
 “wholesome, palatable, and in sufficient quantities.

“Taking

“ Taking advantage of the vapour which ascends in  
 “ the kettle while the ships provisions are boiling.

“ All these advantages are obtained by the above-  
 “ mentioned simple addition to the common ship’s  
 “ kettles. But Doctor Irving proposes to introduce  
 “ two further improvements.

“ The first is a hearth, or stove, so constructed,  
 “ that the fire which is kept up the whole day for  
 “ the common business of the ship, serves likewise  
 “ for distillation; whereby a sufficient quantity of  
 “ water for all the economical purposes of the ship  
 “ may be obtained, with a very inconsiderable ad-  
 “ dition to the expence of fuel.

“ The other improvement is that of substituting,  
 “ even in the largest ships, cast-iron boilers, of a  
 “ new construction, in the place of coppers.”

DIRECTIONS

## DIRECTIONS for DISTILLING SEA-WATER.

“ As soon as sea-water is put into the boiler, the  
“ tube is to be fitted either into the top or lid,  
“ round which, if necessary, a bit of wet linen may  
“ be applied, to make it fit close to the mouth of  
“ the vessel; there will be no occasion for luting,  
“ as the tube acts like a funnel in carrying off the  
“ vapour.

“ When the water begins to boil, the vapour  
“ should be allowed to pass freely for a minute,  
“ which will effectually clean the tube and upper  
“ part of the boiler. The tube is afterwards to be  
“ kept constantly wet, by passing a mop or swab,  
“ dipped in sea-water, along its upper surface.  
“ The waste water running from the mop, may be  
“ carried off by means of a board, made like a  
“ spout, and placed beneath the tube.

“ The distillation may be continued till three  
“ fourths of the water be drawn off, and no further.  
“ This may be ascertained either by a gauge-rod put  
“ into the boiler, or by measuring the water distilled.  
“ The brine is then to be let out.

“ Water may be distilled in the same manner  
“ while the provisions are boiling.

“ When

“ When the tube is made on shore, the best  
 “ substance for the purpose is thin copper well  
 “ tinned, this being more durable in long voyages  
 “ than tin plates.

“ Instead of mopping, the tube, if required,  
 “ may have a case made also of copper, so much  
 “ larger in diameter as to admit a thin sheet of  
 “ water to circulate between them, by means of a  
 “ spiral copper thread, with a pipe of an inch dia-  
 “ meter at each end of the case; the lower for  
 “ receiving cold water, and the upper for carrying  
 “ it off when heated.

“ When only a very small portion of room can be  
 “ conveniently allowed for distillation, the machine,  
 “ which is only twenty-seven inches long, may be  
 “ substituted, as was done in this voyage. The  
 “ principal intention of this machine, however, is  
 “ to distil rum and other liquors; for which purpose  
 “ it has been employed with extraordinary success,  
 “ in preventing an *empyreuma*, or fiery taste.”

ACCOUNT of the ASTRONOMICAL OBSERVATIONS  
and TIME-KEEPERS, by Mr. LYONS.

“ **T**HE observations for finding the time at sea,  
 “ were taken with a brass Hadley’s Sextant  
 “ of eighteen inches radius, made by Dollond;  
 “ and sometimes by Captain Phipps, with a smaller  
 “ of four inches radius, made by Ramsden, which  
 “ commonly agreed with the other within a mi-  
 “ nute. The error of the sextant was generally  
 “ found by observing the diameter of the Sun;  
 “ which if the same as double the semidiameter  
 “ set down in the Nautical Almanac, shewed that  
 “ the instrument was perfectly adjusted; if it dif-  
 “ fered, the difference was the error of the sextant.  
 “ It was necessary to know this error of adjustment  
 “ very exactly, and therefore I generally repeated  
 “ the observation of the Sun’s diameter several  
 “ times, and from the mean of the result found  
 “ the error of the sextant. This error will equally  
 “ affect all the observations taken near the same  
 “ time, and therefore cannot be discovered from  
 “ the comparison of several observations. Under  
 “ the equator, an error of one minute in altitude,  
 “ near the prime vertical, will only produce an er-  
 “ ror of four seconds in the apparent time; but in  
 “ the latitude of eighty degrees it will cause an  
 “ error of twenty-three seconds. As we generally  
 “ took

“ took several successive observations, any error in  
 “ the observation itself will be generally independent of the rest ; and as I have calculated each  
 “ separately, the conclusions will shew which are  
 “ erroneous, by their differing much from the  
 “ mean of all, which cannot but be very near the  
 “ truth.

“ In calculating these observations, I found by  
 “ the logboard how much we had altered our latitude since the last observation ; and sometimes,  
 “ when we had an observation the noon following the observation for the time, the latitude of the  
 “ ship at the time the altitudes were taken was inferred from it. As most of our altitudes were  
 “ observed when the sun was near the prime vertical, a small error in the latitude will not produce  
 “ any considerable change in the time ; indeed, if it is exactly in the prime vertical, it  
 “ will not make any change at all.

“ To find the Longitude from these observations : to the apparent time found by calculation,  
 “ apply the equation of time according to its sign,  
 “ which will give the mean time ; the difference  
 “ between which and that marked by the watch,  
 “ will shew how much it is too slow or too fast for  
 “ mean time.

“ Captain

## 212 A P P E N D I X.

“ Captain Phipps’s pocket watch, made by Mr.  
 “ Arnold, when compared with the regulator at  
 “ Greenwich, May 26th, was twenty-four seconds  
 “ too slow; it was there found to lose twelve se-  
 “ conds and a quarter a day on mean time. From  
 “ this it is easy to find what time it is at Greenwich  
 “ at any moment shewn by the watch.

“ The watch was compared every day about  
 “ noon with the two time-keepers made by Mess.  
 “ Arnold and Kendal; and from this comparison,  
 “ and their rates of going previously settled at  
 “ Greenwich, together with knowing how much  
 “ they differed from mean time at Greenwich be-  
 “ fore we set out, was calculated the table which  
 “ shews what the mean time is at Greenwich ac-  
 “ cording to each time-keeper, when the watch is  
 “ at twelve hours.

“ By the help of this table, we may easily find  
 “ the longitude of the ship, as deduced from the  
 “ going of each time-keeper. Having found how  
 “ much the watch is too fast or too slow for mean  
 “ time at the ship, we know what the mean time  
 “ is at the ship when the watch is at twelve hours;  
 “ and by the table we can find what is the mean  
 “ time at Greenwich at the same time, supposing  
 “ each time-keeper had kept the same rate of go-  
 “ ing as it had before our departure: the difference  
 “ of these mean times will give the longitude of the  
 “ ship.

“ For

" For example, June 19th, in the afternoon,  
 " the watch was  $1^{\circ} 24''$  too slow for mean time at  
 " the place where we observed; therefore, when  
 " the watch shews twelve hours, the mean time  
 " at this place was  $12^{\text{h}} 1^{\circ} 24''$ . At this time I find  
 " by the table, that according to Kendal's time-  
 " keeper, the mean time at Greenwich was  $12^{\text{h}}$   
 "  $2^{\circ} 7''$ : from this subtracting  $12^{\text{h}} 1^{\circ} 24''$ , the  
 " mean time at the ship, the remainder,  $0^{\circ} 43''$  is  
 " the difference of meridians; which, converted  
 " into parts of a degree, gives  $0^{\circ} 10' 45''$  for the  
 " longitude of the ship according to Kendal, which  
 " is to the Westward, because the mean time at  
 " the ship is less than that at Greenwich.

" When we were on shore, the observations  
 " were made with an Astronomical Quadrant, di-  
 " vided by Mr. Ramsden, of eighteen inches ra-  
 " dius, which was placed on a solid rock of mar-  
 " ble; the error of the line of collimation was  
 " found by inverting the quadrant, which was ad-  
 " justed by a spirit level. The weather did not  
 " permit us to take corresponding altitudes of the  
 " Sun, so that we determined the apparent time  
 " by computation from altitudes of the Sun's limb;  
 " having before settled the latitude of the place  
 " of observation, from meridian altitudes of the  
 " Sun's limbs taken with the same instrument.



“ The Latitudes of the ship were determined  
 “ most commonly by the meridian altitude of the  
 “ Sun’s lower limb ; in a few instances, by that of  
 “ his upper limb, when the lower was not so di-  
 “ stinct, or was hid by clouds. The height of the  
 “ eye above the level of the sea, in all these obser-  
 “ vations, was sixteen feet. When we could not  
 “ get a meridian observation, we made use of the  
 “ method described in the Nautical Almanac for  
 “ 1771, from two altitudes taken about noon, and  
 “ at a little distance from it.

“ It sometimes happens that we can only take  
 “ some altitudes very near the time of noon. If  
 “ we have observed any altitudes of the Sun near  
 “ the prime vertical, we may thence determine  
 “ how much the watch is too fast or too slow for  
 “ apparent time ; and consequently, how much the  
 “ time when the altitudes were taken, is distant  
 “ from noon ; it therefore remains to find how  
 “ much these altitudes are different from the me-  
 “ ridian altitude. This may easily be found by  
 “ the following Rule :

“ To the logarithm of the rising, taken out of the  
 “ tables in the Nautical Almanac for 1771, add the  
 “ complement arithmetical of the logarithmic co-  
 “ sine of the supposed meridian altitude ; from the  
 “ sum (the index being increased by five) subtract  
 “ the logarithm ratio (found by the rules in the  
 “ abovementioned Ephemeris) the remainder is the  
 “ logarithmic sine of the change in altitude.

“ E X A M P L E

" June the twenty-first, the altitude of the Sun's center was observed to be  $46^{\circ} 6'$  at  $16' 45''$  after apparent noon; the latitude by account was  $67^{\circ} 17'$ ; the Sun's declination being then  $23^{\circ} 28' N$ , the supposed meridian altitude  $46^{\circ} 11'$ .

" Supposed Latitude  $67^{\circ} 17'$  Co. Ar. Cos.  $0.41322$ . Rising  $16' 45''$  . . . 2,42643  
 " Sun's declination  $23^{\circ} 28'$  Co. Ar. Cos.  $0.03749$ . Supposed Mer. Alt. Ar. Co. Cos. . . 0,15967

" Log. Ratio 0,45071  
 " The change in Altitude is  $+0^{\circ} 5'$  . . . . . Sine 7,13539  
 " Observed Altitude  $46^{\circ} 0'$

" Meridian Altitude  $46^{\circ} 11'$   
 " Declination  $23^{\circ} 28'$

" Altitude of the Equator  $23^{\circ} 43'$   
 " Latitude  $67^{\circ} 17' N$

" As the altitudes for determining how much the watch differs from apparent time were taken near the prime vertical, a great error in the supposed latitude will make a very insensible change in the apparent time; nor will it create any great difference in the variation of altitude near noon in a given time, as will appear by the following computation:

" Suppose the latitude by account was  $68^{\circ} 17'$ , a degree greater than before.

|                                       |                      |                     |                              |              |              |
|---------------------------------------|----------------------|---------------------|------------------------------|--------------|--------------|
| " Supposed Latitude $68^{\circ} 17'$  | Col. Co. Ar. 0,43178 | Rising $16' 45''$   | —                            | —            | 5.           |
| " Declination 23 28                   | —                    | 0,03749             | Supposed Mer. Alt. $45. 18.$ | Col. Co. Ar. | 2,42643      |
|                                       |                      |                     |                              |              | 0,15191      |
|                                       |                      |                     |                              |              | <hr/>        |
| " Log. Ratio 0,46927                  |                      |                     |                              |              | 7,57834      |
|                                       |                      |                     |                              |              | 0,46927      |
|                                       |                      |                     |                              |              | <hr/>        |
| " The change in the Sun's Altitude is |                      | $0^{\circ} 4' 25''$ |                              |              | Sine 7,10907 |
| " Observed Altitude                   |                      | 46 6                |                              |              | —            |

|                     |          |
|---------------------|----------|
| " Meridian Altitude | 46 10 25 |
| " Declination       | 23 28    |
|                     | <hr/>    |

" Altitude of the Equator 22 42 25  
 " Latitude 67 17 35 which only differs thirty-five seconds from  
 " the true latitude we found before.

E X A M P L E II.

" June the twentieth, the altitude of the Sun's center was observed on 28' 38" after midnight,  
 " to be  $1^{\circ} 13'$ , the latitude by account being  $67^{\circ} 40' N$ .

|                     |                  |              |         |                    |                             |
|---------------------|------------------|--------------|---------|--------------------|-----------------------------|
| " Supposed Latitude | $67^{\circ} 40'$ | Cof. Co. Ar. | 0.42022 | Rising 28' 38"     | —                           |
| " Declination       | 23 28            | —            | 0.03749 | Supposed Mer. Alt. | $1^{\circ} 8'$ Cof. Co. Ar. |
|                     |                  |              |         |                    | <hr/>                       |

5.  
 2,89380  
 0,00001

---

 7,89381  
 0,45771

" Log. Ratio 0,45771

" Change in the Altitude —  $0^{\circ} 9'$   
 " Observed Altitude 1 13

" Meridian Altitude 1 4  
 " Co-Declination 66 32

---

 " Latitude 67 36 N

" There

“ There were two time-keepers sent out for trial  
“ by the Board of Longitude; one made by Mr.  
“ Kendal after Mr. Harrison's principles; the other,  
“ by Mr. Arnold: this last was suspended in gim-  
“ mals, but Mr. Kendal's was laid between two  
“ cushions which quite filled up the box. They  
“ were both kept in boxes screwed down to the  
“ shelves of the cabin, and had each three locks;  
“ the key of one of which was kept by the cap-  
“ tain, of another by the first lieutenant, and of  
“ the third by myself; they were wound up each  
“ day soon after noon, and compared with each  
“ other and with Captain Phipps's watch. They  
“ stopped twice in the voyage, owing to their being  
“ run down; they were set a-going again, and as  
“ they had been daily compared together, it was  
“ easy to know how long each had stopped, from  
“ the others that were still going; this time is al-  
“ lowed for in the table of the mean time at Green-  
“ wich by each time-keeper.

“ When we were on shore at the island where  
“ we observed July 15th, we found how much the  
“ watch was too slow for mean time. When we re-  
“ turned from the ice to Smeerenberg, and again  
“ compared the watch with the mean time, allow-  
“ ing the same difference of longitude between the  
“ island and Smeerenberg, we found that it went  
“ very nearly at the same rate, as it did when tried  
“ at Greenwich: so that its rate of going was nearly  
“ the same in our run from England to the island,  
“ from

“ from thence to the ice and back again to Smeeren-  
 “ berg, and in our voyage from thence to England, as  
 “ we found on our return. By this means we were in-  
 “ duced to give the preference to the watch, and  
 “ to conclude that the longitude found by it was  
 “ not very different from the truth.

“ The principles on which this watch is con-  
 “ structed, as I am informed by the maker, Mr.  
 “ Arnold, are these: the balance is unconnected  
 “ with the wheel-work, except at the time it re-  
 “ ceives the impulse to make it continue its mo-  
 “ tion, which is only while it vibrates  $10^{\circ}$  out of  
 “  $380^{\circ}$ , which is the whole vibration; and during  
 “ this small interval it has little or no friction, but  
 “ what is on the pivots, which work in ruby holes  
 “ on diamonds: it has but one pallet, which is a  
 “ plane surface formed out of a ruby, and has no  
 “ oil on it.

“ Watches of this construction go whilst they  
 “ are wound up; they keep the same rate of going  
 “ in every position, and are not affected by the dif-  
 “ ferent forces of the spring: the compensation  
 “ for heat and cold is absolutely adjustable.

“ Time-keepers of this size are more convenient  
 “ than larger, on several accounts; they are equally  
 “ portable with a pocket watch, and by being kept  
 “ nearly in the same degree of heat, suffer very  
 “ little or no change from the vicissitudes of the  
 “ weather.

" This watch was exceedingly useful to us in  
 " our observations on land, as the other time-keep-  
 " ers could not safely be moved: and indeed, in  
 " the present voyage, where they were on trial, it  
 " was contrary to the intent for which they were  
 " put on board, and might have been attended  
 " with accidents by which the rate of their going  
 " might have been greatly affected.

" The longitudes by Mr. Arnold's larger time-  
 " keeper are very different from those by the  
 " watch in our voyage back from Spitzbergen to  
 " England; owing, probably, to the balance-spring  
 " being rusted, as we found when it was opened at  
 " the Royal Observatory at Greenwich, on our  
 " return.

" The longitudes found by the Moon are de-  
 " duced from distances of the Moon from the Sun's  
 " limbs, or from Stars, taken with the sextant;  
 " whilst the altitudes of the Moon and Sun, or  
 " Star, were taken by two other observers.

" In one instance (June 26th) the observations  
 " were all made by Captain Phipps with the small  
 " sextant successively; and the altitudes of the  
 " Moon and Sun at the very instant the distances  
 " were observed, are deduced from the changes  
 " in these altitudes during the interval of observa-  
 " tion.

" I have

“ I have calculated the longitude from each set  
 “ of observations separately, to shew how near  
 “ they agree with each other, and what degree  
 “ of precision one may expect in similar cases.

“ Observations of the distances of the Moon and  
 “ Sun, or Stars, may be useful to inform us if the  
 “ time-keepers have suffered any considerable  
 “ change in their rate of going. For if the longi-  
 “ tude deduced from the moon differs above two  
 “ degrees from that found by the watches, it is  
 “ reasonable to imagine, that this difference is  
 “ owing to some fault in the watch, as the longi-  
 “ tude found by lunar observations can hardly vary  
 “ this quantity from the truth: but if the differ-  
 “ ence is much less, as about half a degree, it is  
 “ more probable that the watch is right, since a  
 “ small error in the distance will produce this dif-  
 “ ference.

“ The distances of the Moon from Jupiter were  
 “ observed, because Jupiter is a very bright object;  
 “ and the observations are easier and less fallacious,  
 “ particularly that of the altitude, than those of  
 “ a fixed star, whose light is much fainter. This  
 “ method, however, requires a different form of  
 “ calculation, from that of the observed distance of  
 “ the Moon from a fixed star, whose distances are  
 “ computed for every three hours, in the Nautical  
 “ Almanac. The principal difficulty in the calcu-  
 “ lation is to find the Moon's longitude from the ob-  
 “ servation



“ fervation of the diftance. This I have endeavour-  
 “ ed to facilitate by the following problem, which  
 “ may be applied to any zodiacal ftar, and will be of  
 “ ufe when the ftar fet down in the Ephemeris  
 “ cannot be obferved.

### “ P R O B L E M.

“ Having given the diftance of two objects near  
 “ ecliptic, with their latitudes, to find their dif-  
 “ ference of longitude.

### “ S O L U T I O N.

“ Find an arc A, whole logarithmic fine is the  
 “ fum of the logarithms of the fines of the  
 “ two latitudes and the logarithmic tangent of  
 “ half the diftance, rejecting twenty from the in-  
 “ dex of the fum.

“ Find an arc B, whole logarithmic fine is the  
 “ fum of the logarithmic verfed fine of the differ-  
 “ ence of latitude, and the logarithmic cotangent  
 “ of the diftance, rejecting ten from the index of  
 “ the fum.

“ Then A added to the obferved diftance, and  
 “ B fubtracted from the fum, leaves the difference  
 “ of longitude.

“ If one of the latitudes is South, and the other  
 “ North, the fum of the two arcs A and B fub-  
 “ tracted from the diftance, leaves the difference  
 “ of longitude.

“ EXAMPLE.

" E X A M P L E .

" August the thirty-first, the observed distance of the Moon's center from Jupiter, cleared of refraction and parallax, was  $32^{\circ} 35' 52''$ , the Moon's latitude being  $1^{\circ} 47' N$ , and that of Jupiter  $1^{\circ} 36' S$ .

" Latitude D  $1^{\circ} 47'$  Sine 8,4930 Difference of Latitude,  $3^{\circ} 23'$  Vers. Sine 7,2413

" Latitude 24 - 1 36 Sine 8,4459

" Half distance 16 18 Tang. 9,4660

" Arc A  $0' 52''$  - - Sine 26,4049 Arc B.  $9' 25''$  - - - Sine 17,4354

" The sum of these Arcs —  $10' 17''$  Subtracted from

" the distance -  $32^{\circ} 35' 52''$

" leaves 32 25 35 the Difference of Longitude between the Moon and Jupiter.

" Knowing the longitude of Jupiter from the Ephemeris, and the difference between it and that of the Moon, we may infer the longitude of the Moon by observation: and from the longitudes set down for noon and midnight of each day in the Nautical Almanac, find the apparent time at Greenwich when the moon had that longitude, which compared with the apparent time at the Ship, will give the difference of meridians. A Table

A Table shewing what the Mean Time is at Greenwich, by each Time-keeper, when the Pocket-Watch made by Arnold is at 12<sup>h</sup>.

| Day of the Month. |    | Arnold. |    |    | Kendal. |    |    | Watch. |   |    |
|-------------------|----|---------|----|----|---------|----|----|--------|---|----|
|                   |    | h       | i  | "  | h       | i  | "  | h      | i | "  |
| June              | 2  | 12      | 0  | 38 | 11      | 59 | 56 | 12     | 1 | 49 |
|                   | 3  | 12      | 1  | 1  | 12      | 0  | 14 | 12     | 2 | 2  |
|                   | 4  | 12      | 1  | 16 | 12      | 0  | 25 | 12     | 2 | 15 |
|                   | 5  | 12      | 1  | 36 | 12      | 0  | 45 | 12     | 2 | 27 |
|                   | 6  | 12      | 1  | 50 | 12      | 0  | 55 | 12     | 2 | 39 |
|                   | 7  | 12      | 2  | 6  | 12      | 1  | 10 | 12     | 2 | 51 |
|                   | 8  | 12      | 2  | 8  | 12      | 1  | 10 | 12     | 3 | 4  |
|                   | 9  | 12      | 1  | 50 | 12      | 0  | 53 | 12     | 3 | 16 |
|                   | 10 | 12      | 2  | 3  | 12      | 1  | 5  | 12     | 3 | 28 |
|                   | 11 | 12      | 2  | 11 | 12      | 1  | 28 | 12     | 3 | 40 |
|                   | 12 | 12      | 2  | 16 | 12      | 1  | 34 | 12     | 3 | 53 |
|                   | 13 | 12      | 2  | 4  | 12      | 1  | 28 | 12     | 4 | 5  |
|                   | 14 | 12      | 2  | 10 | 12      | 1  | 38 | 12     | 4 | 17 |
|                   | 15 | 12      | 2  | 16 | 12      | 1  | 48 | 12     | 4 | 29 |
|                   | 16 | 12      | 1  | 59 | 12      | 1  | 35 | 12     | 4 | 42 |
|                   | 17 | 12      | 2  | 6  | 12      | 1  | 48 | 12     | 4 | 54 |
|                   | 18 | 12      | 2  | 5  | 12      | 1  | 51 | 12     | 5 | 6  |
|                   | 19 | 12      | 2  | 14 | 12      | 2  | 7  | 12     | 5 | 18 |
|                   | 20 | 12      | 2  | 2  | 12      | 2  | 3  | 12     | 5 | 31 |
|                   | 21 | 12      | 1  | 57 | 12      | 2  | 5  | 12     | 5 | 43 |
|                   | 22 | 12      | 1  | 43 | 12      | 2  | 3  | 12     | 5 | 55 |
|                   | 23 | 12      | 1  | 13 | 12      | 1  | 30 | 12     | 6 | 8  |
|                   | 24 | 12      | 1  | 2  | 12      | 1  | 39 | 12     | 6 | 20 |
|                   | 25 | 12      | 0  | 24 | 12      | 1  | 17 | 12     | 6 | 32 |
|                   | 26 | 11      | 59 | 52 | 12      | 0  | 59 | 12     | 6 | 44 |
|                   | 27 | 11      | 59 | 44 | 12      | 1  | 4  | 12     | 6 | 57 |
|                   | 28 | 11      | 59 | 26 | 12      | 1  | 2  | 12     | 7 | 9  |
|                   | 29 | 11      | 59 | 11 | 12      | 1  | 3  | 12     | 7 | 21 |
|                   | 30 | 11      | 58 | 55 | 12      | 0  | 59 | 12     | 7 | 31 |
| July              | 1  | 11      | 58 | 45 | 12      | 1  | 7  | 12     | 7 | 46 |
|                   | 2  | 11      | 58 | 29 | 12      | 1  | 10 | 12     | 7 | 58 |
|                   | 3  | 11      | 58 | 20 | 12      | 1  | 21 | 12     | 8 | 10 |
|                   | 4  | 11      | 58 | 14 | 12      | 1  | 31 | 12     | 8 | 23 |
|                   | 5  | 11      | 58 | 2  | 12      | 1  | 39 | 12     | 8 | 35 |
|                   | 6  | 11      | 57 | 50 | 12      | 1  | 47 | 12     | 8 | 47 |
|                   | 7  | 11      | 57 | 42 | 12      | 1  | 59 | 12     | 8 | 59 |
|                   | 8  | 11      | 57 | 26 | 12      | 2  | 10 | 12     | 0 | 12 |

A Table shewing what the Mean Time is at Greenwich, by each Time-keeper, when the Pocket-Watch made by Arnold is at 12<sup>b</sup>.

| Day of the Month. | Arnold. |    |    | Kendal. |   |    | Watch. |    |    |
|-------------------|---------|----|----|---------|---|----|--------|----|----|
|                   | h       | i  | "  | h       | i | "  | h      | i  | "  |
| July 9            | 11      | 57 | 20 | 12      | 2 | 25 | 12     | 9  | 24 |
| 10                | 11      | 56 | 59 | 12      | 2 | 33 | 12     | 9  | 36 |
| 11                | 11      | 56 | 47 | 12      | 2 | 45 | 12     | 9  | 49 |
| 12                | 11      | 56 | 25 | 12      | 2 | 45 | 12     | 10 | 1  |
| 13                | 11      | 56 | 13 | 12      | 2 | 58 | 12     | 10 | 13 |
| 14                | 11      | 55 | 33 | 12      | 2 | 44 | 12     | 10 | 25 |
| 15                | .       | .  | .  | .       | . | .  | 12     | 10 | 38 |
| 16                | 11      | 55 | 20 | 12      | 2 | 34 | 12     | 10 | 50 |
| 17                | 11      | 55 | 5  | 12      | 2 | 52 | 12     | 11 | 2  |
| 18                | 11      | 54 | 56 | 12      | 3 | 18 | 12     | 11 | 14 |
| 19                | 11      | 54 | 21 | 12      | 3 | 22 | 12     | 11 | 27 |
| 20                | 11      | 54 | 1  | 12      | 3 | 32 | 12     | 11 | 39 |
| 21                | 11      | 53 | 39 | 12      | 3 | 59 | 12     | 11 | 51 |
| 22                | 11      | 53 | 15 | 12      | 4 | 18 | 12     | 12 | 4  |
| 23                | 11      | 52 | 50 | 12      | 4 | 38 | 12     | 12 | 16 |
| 24                | 11      | 52 | 15 | 12      | 4 | 47 | 12     | 12 | 28 |
| 25                | 11      | 51 | 48 | 12      | 5 | 9  | 12     | 12 | 40 |
| 26                | 11      | 51 | 10 | 12      | 5 | 16 | 12     | 12 | 53 |
| 27                | 11      | 50 | 34 | 12      | 5 | 27 | 12     | 13 | 5  |
| 28                | 11      | 49 | 59 | 12      | 5 | 48 | 12     | 13 | 17 |
| 29                | 11      | 49 | 31 | 12      | 6 | 12 | 12     | 13 | 29 |
| 30                | 11      | 48 | 57 | 12      | 6 | 40 | 12     | 13 | 42 |
| 31                | 11      | 48 | 9  | 12      | 6 | 52 | 12     | 13 | 54 |
| Aug. 1            | 11      | 47 | 24 | 12      | 7 | 0  | 12     | 14 | 6  |
| 2                 | 11      | 46 | 34 | 12      | 7 | 12 | 12     | 14 | 19 |
| 3                 | 11      | 45 | 50 | 12      | 7 | 32 | 12     | 14 | 31 |
| 4                 | 11      | 44 | 39 | 12      | 7 | 34 | 12     | 14 | 43 |
| 5                 | 11      | 43 | 43 | 12      | 7 | 38 | 12     | 14 | 55 |
| 6                 | 11      | 42 | 36 | 12      | 7 | 31 | 12     | 15 | 8  |
| 12                | 11      | 58 | 7  | .       | . | .  | .      | .  | .  |
| 13                | 11      | 56 | 32 | .       | . | .  | .      | .  | .  |
| 14                | 11      | 55 | 16 | 12      | 5 | 21 | 12     | 16 | 45 |
| 15                | 11      | 54 | 3  | 12      | 5 | 38 | 12     | 16 | 58 |
| 16                | 11      | 52 | 46 | 12      | 5 | 53 | 12     | 17 | 10 |
| 17                | 11      | 51 | 27 | 12      | 6 | 10 | 12     | 17 | 23 |
| 18                | 11      | 50 | 8  | 12      | 6 | 33 | 12     | 17 | 35 |
| 19                | 11      | 48 | 41 | 12      | 6 | 38 | 12     | 17 | 47 |

A Table shewing what the Mean Time is at Greenwich, by each Time-keeper, when the Pocket Watch made by Arnold is at 12<sup>h</sup>.

| Day of the Month. | Arnold. |    |    | Kendal. |    |    | Watch. |    |    |
|-------------------|---------|----|----|---------|----|----|--------|----|----|
|                   | h       | '  | "  | h       | '  | "  | h      | '  | "  |
| Aug. 20           | 11      | 47 | 7  | 12      | 6  | 52 | 12     | 18 | 0  |
| 21                | 11      | 45 | 23 | 12      | 6  | 58 | 12     | 18 | 12 |
| 22                | 11      | 43 | 34 | 12      | 6  | 47 | 12     | 18 | 24 |
| 23                | 11      | 41 | 51 | 12      | 6  | 55 | 12     | 18 | 36 |
| 24                | 11      | 39 | 51 | 12      | 6  | 58 | 12     | 18 | 49 |
| 25                | 11      | 37 | 56 | 12      | 6  | 56 | 12     | 19 | 1  |
| 26                | 11      | 35 | 56 | 12      | 6  | 58 | 12     | 19 | 13 |
| 27                | 11      | 34 | 7  | 12      | 7  | 15 | 12     | 19 | 25 |
| 28                | 11      | 32 | 17 | 12      | 7  | 32 | 12     | 19 | 38 |
| 29                | 11      | 30 | 17 | 12      | 7  | 32 | 12     | 19 | 50 |
| 30                | 11      | 28 | 9  | 12      | 7  | 43 | 12     | 20 | 2  |
| 31                | 11      | 26 | 14 | 12      | 7  | 57 | 12     | 20 | 15 |
| Sept. 1           | 11      | 24 | 5  | 12      | 8  | 13 | 12     | 20 | 27 |
| 2                 | 11      | 21 | 46 | 12      | 8  | 13 | 12     | 20 | 39 |
| 3                 | 11      | 19 | 43 | 12      | 8  | 38 | 12     | 20 | 51 |
| 4                 | 11      | 17 | 29 | 12      | 8  | 53 | 12     | 21 | 4  |
| 5                 | 11      | 14 | 59 | 12      | 9  | 4  | 12     | 21 | 16 |
| 6                 | 11      | 12 | 22 | 12      | 9  | 22 | 12     | 21 | 28 |
| 7                 | 11      | 9  | 38 | 12      | 9  | 22 | 12     | 21 | 40 |
| 9                 | 11      | 3  | 53 | 12      | 9  | 44 | 12     | 22 | 5  |
| 11                | 10      | 57 | 16 | 12      | 9  | 46 | 12     | 22 | 30 |
| 13                | 10      | 50 | 45 | 12      | 10 | 16 | 12     | 22 | 54 |
| 14                | 10      | 35 | 0  | 12      | 10 | 31 | 12     | 23 | 6  |
| 15                | 10      | 42 | 31 | 12      | 10 | 47 | 12     | 23 | 19 |
| 16                | 10      | 39 | 35 | 12      | 11 | 4  | 12     | 23 | 31 |
| 17                | 10      | 35 | 59 | 12      | 11 | 31 | 12     | 23 | 43 |
| 18                | 10      | 31 | 53 | 12      | 11 | 47 | 12     | 23 | 56 |
| 19                | 10      | 27 | 11 | 12      | 11 | 52 | 12     | 24 | 8  |
| 20                | 10      | 23 | 0  | 12      | 12 | 15 | 12     | 24 | 20 |
| 21                | 10      | 18 | 38 | 12      | 12 | 40 | 12     | 24 | 32 |
| 23                | 10      | 8  | 54 | 12      | 13 | 39 | 12     | 24 | 57 |
| 24                | 10      | 4  | 13 | 12      | 14 | 10 | 12     | 25 | 9  |
| 25                | 9       | 58 | 52 | 12      | 14 | 37 | 12     | 25 | 21 |
| 26                | 9       | 53 | 54 | 12      | 14 | 59 | 12     | 25 | 34 |
| 27                | 9       | 48 | 8  | 12      | 15 | 35 | 12     | 25 | 46 |

## Observations for finding the Longitude by the Time-keepers.

May 30, P. M. off Sheerness.

| Time by the Watch.  | Alt. of the Sun's low. Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time.  | Watch too slow. | Mean of the two last, 3' 15" | Eq. Time 2'—50" |
|---|------------------------------|---------------------------|----------------|-------------|-----------------|------------------------------|-----------------|
| h m s   | ° ' "                        | ° ' "                     | h m s          | h m s       | ' "             | h m s                        | h m s           |
| 5 48 4  | 17 46 0                      | 17 55 0                   | 5 53 47        | 5 50 57     | 2 11            |                              |                 |
| 5 51 12   | 17 14 0                      | 17 23 0                   | 5 57 25        | 5 54 35     | 3 23            |                              |                 |
| 5 53 12   | 16 57 0                      | 17 6 0                    | 5 59 10        | 5 56 20     | 3 8             |                              |                 |
| At 12 <sup>h</sup> by the Watch, mean Time at the Ship, 12 3 15 . . . 12 3 15 . . . 12 3 15 |                              |                           |                |             |                 |                              |                 |
| At Greenwich, by the Watch, 12 1 13 by Arnold, 12 0 27 by Kendal, 11 59 45                  |                              |                           |                |             |                 |                              |                 |
| Difference of Meridians,  |                              |                           |                | 0 2 2       | 0 2 48          | 0 2 48                       | 0 3 26          |
| Longitude of the Ship,  |                              |                           |                | 0° 30' 30"E | 0° 42' 0"       | 0° 42' 0"                    | 0° 51' 30"      |

Observations

Observations for finding the Longitude by the Time-keepers.

June 13, P. M.

| Time by<br>Arnold.                                  | Alt. of the<br>Sun's lower<br>Limb. | Alt. of the<br>Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Arnold<br>too<br>slow. |                               |           |
|---|-------------------------------------|---------------------------------|-------------------|---------------|------------------------|-------------------------------|-----------|
| h m s   | o ' "                               | o ' "                           | h m s             | h m s         | h m s                  | Lat.                          | Eq. Time, |
| 5 36 22   | 22 10 30                            | 22 18 0                         | 5 41 6            | 5 40 44       | 4 22 *                 | 59 46 0                       | 0—22      |
| 5 38 55   | 21 52 0                             | 21 59 30                        | 5 43 18           | 5 42 56       | 4 1 *                  |                               |           |
| 5 39 57   | 21 44 30                            | 21 54 10                        | 5 44 20           | 5 43 58       | 4 1 *                  |                               |           |
| 5 41 17   | 21 35 0                             | 21 42 30                        | 5 46 25           | 5 46 3        | 4 46                   |                               |           |
| 5 43 3  | 21 20 0                             | 21 27 30                        | 5 48 8            | 5 47 46       | 4 43                   | Mean of the<br>five marked *, |           |
| 5 45 5  | 21 6 30                             | 21 13 50                        | 5 49 43           | 5 49 21       | 4 12                   | 4' 8"                         |           |
| 5 47 40   | 20 46 30                            | 20 56 0                         | 5 52 7            | 5 51 45       | 4 5 *                  |                               |           |
|   | 20 47                               | 20 54 20                        | 5 52 53           | 5 52 31       | 4 51 *                 |                               |           |
| At 6 <sup>h</sup> by Arnold, mean Time at the Ship, |                                     |                                 | 6 4 8             | 6 4 8         | h ' "                  | h ' "                         |           |
| At Greenwich, by the Watch,                         |                                     |                                 | 6 3 52 by Arnold, | 6 4 8         | 6 4 8                  | 6 4 8                         |           |
| Difference of Meridians,                            |                                     |                                 | 0 0 16            | 0 2 19        | 0 2 19                 | 0 2 54                        |           |
| Longitude of the Ship,                              |                                     |                                 | 0° 4' 0" E        | 0° 34' 45"    | 0° 34' 45"             | 0° 43' 30"                    |           |

Observations

Observations for finding the Longitude by the Time-keepers.

June 14, A. M.

| Time by<br>Arnold.                                   | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time.  | Mean<br>Time.      | Arnold<br>too<br>falt. | Lat.<br>Eq. Time |
|--|-------------------------------------|---------------------------------|--------------------|--------------------|------------------------|------------------|
| h / "  | o / "                               | o / "                           | h / "              | h / "              | h / "                  | o / "            |
| 9 44 32  | 45 57 0                             | 46 8 0                          | 9 43 56            | 9 43 43            | 0 49                   | 60 17 0          |
| 9 48 41  | 46 21 0                             | 46 32 0                         | 9 48 20            | 9 48 7             | 0 34                   | 0—13             |
| 9 52 53  | 46 41 0                             | 45 52 0                         | 9 52 4             | 9 51 51            | 1 2                    |                  |
|  |                                     |                                 |                    | h / "              | h / "                  | h / "            |
| At 10 <sup>h</sup> by Arnold, mean Time at the Ship, |                                     |                                 |                    |                    |                        |                  |
| At Greenwich, by the Watch,                          |                                     |                                 |                    |                    |                        |                  |
|  |                                     |                                 | 9 59 12            | 9 59 12            |                        | 9 59 12          |
|  |                                     |                                 | 10 3 59 by Arnold, | 10 1 52 by Kendal, |                        | 10 1 20          |
| Difference of Meridians,                             |                                     |                                 |                    |                    |                        |                  |
| Longitude of the Ship,                               |                                     |                                 |                    |                    |                        |                  |
|  |                                     |                                 | 0 4 47             | 0 2 40             |                        | 0 2 8            |
|  |                                     |                                 | 1° 11' 45" W       | 0° 40' 0"          |                        | 0° 32' 0"        |

Observations



## Observations for finding the Longitude by the Time-keepers.

June 15, A. M.

| Time by<br>Arnold.                                  | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time.     | Arnold<br>too<br>flow. |                             |
|---|-------------------------------------|---------------------------------|-------------------|-------------------|------------------------|-----------------------------|
| h ' "   | o ' "                               | o ' "                           | h ' "             | h ' "             | ' "                    |                             |
| 8 26 48   | 38 3 0                              | 38 13 40                        | 8 28 16           | 8 28 13           | 1 35                   | Lat. 60° 17'                |
| 8 28 5  | 38 11 30                            | 38 22 10                        | 8 29 40           | 8 29 37           | 1 32                   | Mean, 1' 33" Eq. Time, 0—3" |
| 8 29 8  | 38 20 0                             | 38 30 40                        | 8 30 53           | 8 30 50           | 1 42                   |                             |
| At 8 <sup>h</sup> by Arnold, mean Time at the Ship, |                                     |                                 |                   |                   |                        |                             |
| At Greenwich, by the Watch,                         |                                     |                                 |                   |                   |                        |                             |
|   |                                     |                                 | h ' "             | h ' "             |                        | h ' "                       |
|   |                                     |                                 | 8 1 33            | 8 1 33            |                        | 8 1 33                      |
|   |                                     |                                 | 8 4 9 by Arnold,  | 8 1 56 by Kendal, |                        | 8 1 28                      |
| Difference of Meridians,                            |                                     |                                 |                   |                   |                        |                             |
| Longitude of the Ship,                              |                                     |                                 |                   |                   |                        |                             |
|   |                                     |                                 | o° 39' 0" W       | o° 23'            |                        | o° 0 5'                     |
|   |                                     |                                 | o° 5' 45" W       | o° 1' 15" E       |                        |                             |

Observations

## Observations for finding the Longitude by the Time-keepers.

June 17, A. M.

| Time by<br>Arnold.                                   | Alt. of the<br>Sun's lower<br>Limb. | Alt. of the<br>Sun's<br>Center. | Alt. of Apparent<br>Time. | Mean<br>Time. | Arnold<br>too<br>slow. |                                      |             |
|--|-------------------------------------|---------------------------------|---------------------------|---------------|------------------------|--------------------------------------|-------------|
| h m s  | o ' "                               | o ' "                           | h m s                     | h m s         | h m s                  | Lat.                                 | o ' "       |
| 9 33 11  | 43 41 0                             | 43 52 0                         | 9 35 29                   | 9 35 53       | 2 42                   | 62 43 30                             |             |
| 9 34 58  | 43 51 0                             | 44 2 0                          | 9 38 36                   | 9 39 0        | 4 2                    | 23 25 20                             |             |
| 9 36 45  | 44 2 0                              | 44 13 0                         | 9 39 36                   | 9 40 0        | 3 15                   | Mean, 3' 31" Eq. Time,               | 0 + 24      |
| 9 37 40  | 44 6 30                             | 44 17 30                        | 9 40 31                   | 9 41 55       | 4 15                   |                                      |             |
| 9 42 4   | 44 30 0                             | 44 41 0                         | 9 45 13                   | 9 45 37       | 3 33                   |                                      |             |
|  |                                     |                                 | h m s                     | h m s         | h m s                  |                                      |             |
| At 10 <sup>h</sup> by Arnold, mean Time at the Ship, |                                     |                                 |                           |               |                        | 10 3 31                              | h m s       |
| At Greenwich, by the Watch,                          |                                     |                                 |                           |               |                        | 10 4 50 by Arnold, 10 2 2 by Kendal, | 10 3 31     |
| Difference of Meridians,                             |                                     |                                 |                           |               |                        | 0 1 19                               | 0 1 47      |
| Longitude of the Ship,                               |                                     |                                 |                           |               |                        | 0 19' 45" W                          | 0 26' 45" E |

Observations

Observations for finding the Longitude by the Time-keepers.

June 18, P. M.

| Time by<br>the<br>Watch                                 | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>flow. |             |                   |                    |
|---|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|-------------|-------------------|--------------------|
| h / "   | o / "                               | o / "                           | h / "             | h / "         | h / "                 |             |                   |                    |
| 3 32 41   | 35 58 30                            | 36 9 10                         | 3 33 5            | 3 33 45       | 1 4                   |             | Lat.              | 65 25 0            |
| 3 34 24   | 35 50 0                             | 36 0 40                         | 3 34 35           | 3 35 15       | 0 51                  | Mean        | 1' 4"             | Decl. 23 26 10     |
| 3 37 38   | 35 29 0                             | 35 39 40                        | 3 38 15           | 3 38 55       | 1 17                  |             | Eq. Time,         | 0 40               |
| At 12 <sup>o</sup> by the Watch, mean Time at the Ship, |                                     |                                 |                   |               |                       | h / "       | h / "             | h / "              |
| At Greenwich, by the Watch,                             |                                     |                                 |                   |               |                       | 12 1 4      | 12 1 4            | 12 1 4             |
| Difference of Meridians,                                |                                     |                                 |                   |               |                       | 12 5 6      | by Arnold, 12 2 5 | by Kendal, 12 1 51 |
| Longitude of the Ship,                                  |                                     |                                 |                   |               |                       | 0 4 2       | 0 1 1             | 0 0 4              |
|   |                                     |                                 |                   |               |                       | 10 0' 30" W | 00 15' 15"        | 00 11' 45"         |

Observations

## Observations for finding the Longitude by the Time-keepers.

June 19, P. M.

| Time by the Watch. | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. |                                  |                |
|--------------------|-------------------------------|---------------------------|----------------|------------|-----------------|----------------------------------|----------------|
| h ' "              | o ' "                         | o ' "                     | h ' "          | h ' "      | h ' "           |                                  |                |
| 3 55 38            | 33 33 0                       | 33 43 30                  | 3 54 51        | 3 55 45    | 0 7             | *                                | Lat. 66 27 0   |
| 3 56 39            | 33 20 0                       | 33 30 30                  | 3 57 9         | 3 58 3     | 1 24            |                                  | Decl. 23 27 10 |
| 3 58 8             | 33 12 0                       | 33 22 30                  | 3 58 33        | 3 59 27    | 1 49            |                                  | Eq. Time, 0+54 |
| 4 5 28             | 32 30 0                       | 32 40 30                  | 4 5 55         | 4 6 49     | 1 21            | Mean of all but the two marked * |                |
| 4 6 8              | 32 25 0                       | 32 35 30                  | 4 6 47         | 4 7 41     | 1 33            |                                  |                |
| 4 7 57             | 32 16 0                       | 32 26 30                  | 4 8 20         | 4 9 14     | 1 17            |                                  |                |
| 4 8 30             | 32 12 30                      | 32 23 0                   | 4 8 57         | 4 9 51     | 1 21            |                                  | 1' 24"         |
| 6 4 34             | 20 44 30                      | 20 54 0                   | 6 5 19         | 6 6 14     | 1 40            |                                  | Lat. 66 35 0   |
| 6 5 27             | 20 41 0                       | 20 50 30                  | 6 5 54         | 6 6 49     | 1 22            |                                  | Decl. 23 27 0  |
| 6 9 9              | 20 9 0                        | 20 18 20                  | 6 11 25        | 6 12 20    | 3 11            | *                                | Eq. Time, 0+55 |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, 12 1 24 . . . 12 1 24 . . . 12 1 24  
 At Greenwich, by the Watch, 12 5 19 by Arnold, 12 2 14 by Kendal, 12 2 7

Difference of Meridians, 0 3 55  
 Longitude of the Ship, 0° 58' 45" W 0° 12' 30" 0° 10' 45"

Observations

Observations for finding the Longitude by the Time-keepers.

June 21, A. M.

| Time by the Watch. | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. |           |          |
|--------------------|-------------------------------|---------------------------|----------------|------------|-----------------|-----------|----------|
| h m s              | ° ' "                         | ° ' "                     | h m s          | h m s      | h m s           | ° ' "     | ° ' "    |
| 8 50 33            | 37 14 0                       | 37 24 40                  | 8 52 41        | 8 53 56    | 3 23            | Lat.      | 67 35 0  |
| 8 54 0             | 37 30 30                      | 37 41 10                  | 8 56 12        | 8 57 27    | 3 27            | Decl.     | 23 27 55 |
| 8 59 22            | 37 53 0                       | 38 3 40                   | 9 0 57         | 9 2 12     | 2 50            | Eq. Time, | 1 15     |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, h m s 12 3 25  
 At Greenwich, by the Watch, h m s 12 5 43 by Arnold, 12 1 57 by Kendal, 12 2 5

Difference of Meridians, 0 2 18  
 Longitude of the Ship, 0° 34' 30" W 0° 22' 0" E 0° 1 20' 0" E

Observations

## Observations for finding the Longitude by the Time-keepers.

June 25, A. M.

| Time by<br>Arnold.                                  | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Arnold<br>too<br>slow. |                   |                          |
|---|-------------------------------------|---------------------------------|-------------------|---------------|------------------------|-------------------|--------------------------|
| h m s   | ° ' "                               | ° ' "                           | h m s             | h m s         | h m s                  | Lat.              | ° ' "                    |
| 7 58 27   | 32 31 0                             | 32 41 30                        | 8 34 25           | 8 36 32 38 5  |                        | Decl.             | 73 57 0                  |
| 8 0 40  | 32 36 15                            | 32 46 45                        | 8 35 56           | 8 38 33 23    |                        | Eq. Time,         | 23 24 25                 |
| 8 2 58  | 32 42 30                            | 32 53 0                         | 8 37 41           | 8 39 48 36 50 | Mean 37' 36"           |                   | 2+7                      |
| 8 3 52  | 32 46 15                            | 32 56 45                        | 8 39 28           | 8 41 35 37 43 |                        |                   |                          |
| 8 4 58  | 32 50 30                            | 33 1 0                          | 8 40 0            | 8 42 7 37 9   |                        |                   |                          |
| 8 5 42  | 32 54 0                             | 33 4 30                         | 8 41 0            | 8 43 7 37 25  |                        |                   |                          |
| At 8 <sup>h</sup> by Arnold, mean Time at the Ship, |                                     |                                 |                   |               |                        | h m s             | ° ' "                    |
| At Greenwich, by the Watch,                         |                                     |                                 |                   |               |                        | 8 37 36           | 8 37 36                  |
|   |                                     |                                 |                   |               |                        | 8 8 36 by Arnold, | 8 2 28 by Kendal, 8 3 21 |
| Difference of Meridians,                            |                                     |                                 |                   |               |                        | 0 29 0            | 0 34 15                  |
| Longitude of the Ship,                              |                                     |                                 |                   |               |                        | 7° 15' 0" E       | 8° 33' 45"               |

Observations



## Observations for finding the Longitude by the Time-keepers.

June 28, P. M.

| Time by<br>the<br>Watch.   | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. | Mean              | Lat.    | Decl.   | Eq. Time |
|--|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|-------------------|---------|---------|----------|
| h / ' "  | ° / ' "                             | ° / ' "                         | h / ' "           | h / ' "       | h / ' "               | h / ' "           | ° / ' " | ° / ' " | h / ' "  |
| 5 56 50  | 20 45 0                             | 20 54 30                        | 6 33 21           | 6 36 53       | 39 15                 | } Mean<br>38' 29" | 77 30   | 0       |          |
| 5 58 40  | 20 42 0                             | 20 51 30                        | 6 34 18           | 6 37 23       | 38 22                 |                   | 23 16   | 10      |          |
| 5 59 2   | 20 40 0                             | 20 49 30                        | 6 34 55           | 6 37 39       | 38 37                 |                   | 2 44    |         |          |
| At 12 <sup>h</sup> by the Watch, mean Time at the Ship, 12 38 29 . . . 12 38 29 . . . 12 38 29 |                                     |                                 |                   |               |                       |                   |         |         |          |
| At Greenwich, by the Watch, 12 7 9 by Arnold, 12 59 26 by Kendal, 12 1 2                       |                                     |                                 |                   |               |                       |                   |         |         |          |
| Difference of Meridians, 0 31 20   |                                     |                                 |                   |               |                       |                   |         |         |          |
| Longitude of the Ship, 7° 50' 0 E"   |                                     |                                 |                   |               |                       |                   |         |         |          |
| 0 39 3   |                                     |                                 |                   |               |                       |                   |         |         |          |
| 9° 45' 45"   |                                     |                                 |                   |               |                       |                   |         |         |          |
| 0 37 27  |                                     |                                 |                   |               |                       |                   |         |         |          |
| 9° 21' 45"   |                                     |                                 |                   |               |                       |                   |         |         |          |

Observations



## Observations for finding the Longitude by the Time-keepers.

June 29, P. M.

| Time by<br>the<br>Watch.   | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. | Lat.        | Decl. | Eq. Time   |
|--|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|-------------|-------|------------|
| h m s  | ° ' "                               | ° ' "                           | h m s             | h m s         | h m s                 | ° ' "       | ° ' " | h m s      |
| 3 41 37  | 27 29 0                             | 27 39 10                        | 4 22 41           | 4 25 41       | 44 4                  | 78 1 40     |       |            |
| 3 43 25  | 27 20 0                             | 27 30 10                        | 4 25 1            | 4 28 1        | 44 36                 | 23 13 15    |       |            |
| 3 46 30  | 27 11 0                             | 27 21 10                        | 4 28 47           | 4 31 47       | 45 17                 |             |       | 3 10       |
| 3 47 44  | 27 6 0                              | 27 16 10                        | 4 30 28           | 4 33 28       | 45 44                 |             |       |            |
| 3 48 53  | 27 0 0                              | 27 10 10                        | 4 32 36           | 4 35 36       | 46 43                 |             |       |            |
| 3 50 24  | 26 57 0                             | 27 7 10                         | 4 33 29           | 4 36 29       | 46 5                  |             |       |            |
| At 12 <sup>h</sup> by the Watch, mean Time at the Ship, 12 45 25 . . . . . 12 45 25 . . . . . 12 45 25 |                                     |                                 |                   |               |                       |             |       |            |
| At Greenwich, by the Watch, 12 7 21 by Arnold, 11 59 11 by Kendal, 12 1 3                              |                                     |                                 |                   |               |                       |             |       |            |
| Mean 45' 25" Eq. Time  |                                     |                                 |                   |               |                       |             |       |            |
| h m s  |                                     |                                 |                   |               |                       | h m s       |       |            |
| Difference of Meridians, 0 38 4  |                                     |                                 |                   |               |                       | 0 46 14     |       | 0 44 22    |
| Longitude of the Ship, 9° 31' 0"E  |                                     |                                 |                   |               |                       | 11° 33' 30" |       | 11° 5' 30" |

Observations

## Observations for finding the Longitude by the Time-keepers.

June 30, P. M.

| Time by<br>the<br>Watch                                 | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. |  |       |            |
|---|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|--|-------|------------|
| h m s   | ° ' "                               | ° ' "                           | h m s             | h m s         | h m s                 |  |       |            |
| 5 58 43   | 20 27 0                             | 20 36 25                        | 6 40 1            | 6 43 14 44 31 |                       | } Mean<br>45' 29" Eq. Time,            | Lat.  | 78 7 15    |
| 6 0 4   | 20 20 0                             | 20 29 25                        | 6 42 21           | 6 45 34 45 30 |                       |  | Decl. | 23 9 20    |
| 6 1 37  | 20 15 30                            | 20 24 55                        | 6 43 52           | 6 47 5 45 28  |                       |  |       |            |
| 6 2 28  | 20 14 15                            | 20 23 40                        | 6 44 17           | 6 47 30 45 2  |                       |  |       | 3 13       |
|   |                                     |                                 |                   |               |                       | h m s                                  |       | h m s      |
| At 12 <sup>h</sup> by the Watch, mean Time at the Ship, |                                     |                                 |                   |               |                       | 12 45 29                               |       | 12 45 29   |
| At Greenwich, by the Watch                              |                                     |                                 |                   |               |                       | 12 7 34 by Arnold, 11 58 55 by Kendal, |       | 12 0 59    |
| Difference of Meridians,                                |                                     |                                 |                   |               |                       | 0 46 34                                |       | 0 44 30    |
| Longitude of the Ship,                                  |                                     |                                 |                   |               |                       | 9° 28' 45" E                           |       | 11° 7' 30" |

Observations

## Observations for finding the Longitude by the Time-keepers.

July 2, P. M.

| Time by the Watch. | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time.    | Watch too slow. | Lat. Decl. Eq. Time |
|--------------------|-------------------------------|---------------------------|----------------|---------------|-----------------|---------------------|
| 5 46 4             | 20 55 0                       | 21 4 30                   | 6 28 59        | 6 32 34 46 30 |                 | 78 23 50            |
| 5 47 44            | 20 52 0                       | 21 1 30                   | 6 29 59        | 6 33 34 45 50 |                 | 23 0 50             |
| 5 49 59            | 20 47 0                       | 20 56 30                  | 6 31 41        | 6 35 16 45 17 |                 | 3 35                |
| 5 52 57            | 20 41 0                       | 20 50 30                  | 6 33 47        | 6 37 22 44 25 |                 |                     |
| 5 53 55            | 20 37 0                       | 20 46 30                  | 6 35 11        | 6 38 46 44 51 |                 |                     |
| 5 54 49            | 20 35 0                       | 20 44 30                  | 6 35 47        | 6 39 22 44 33 |                 |                     |
| 5 56 35            | 20 30 30                      | 20 40 0                   | 6 37 20        | 6 40 55 44 20 |                 |                     |
|                    |                               |                           |                | h m s         |                 | h m s               |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, 12 44 32 . . . 12 44 32  
 At Greenwich, by the Watch, 12 7 58 by Arnold, 11 58 29 by Kendal, 12 1 10

Difference of Meridians, 0 36 34  
 Longitude of the Ship, 9° 8' 30" E 11° 30' 45" 10° 50' 30"

Observations.

## Observations for finding the Longitude by the Time-keepers.

July 6, P. M.

| Time by<br>the<br>Watch.   | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch.<br>too<br>slow. | Lat.<br>Decl.<br>Eq. Time,<br>Mean, 47' 41" |
|--|-------------------------------------|---------------------------------|-------------------|---------------|------------------------|---|
| h m s  | ° ' "                               | ° ' "                           | h m s             | h m s         | " "                    | ° ' "                                       |
| 6 32 12  | 19 26 0                             | 19 3 40                         | 7 15 59           | 7 20 16       | 48 4                   | 79 57 0                                     |
| 6 36 0   | 19 18 0                             | 18 55 40                        | 7 19 19           | 7 23 36       | 47 36                  | 22 28 20                                    |
| 6 38 35  | 19 13 0                             | 18 50 40                        | 7 21 24           | 7 25 41       | 47 6                   | 4+17  |
| 6 39 23  | 19 9 0                              | 18 46 40                        | 7 23 4            | 7 27 21       | 47 58                  |   |
| 6 40 57  | 19 5 30                             | 18 43 10                        | 7 24 20           | 7 28 37       | 47 40                  |   |
| At 12 <sup>h</sup> by the Watch, mean Time at the Ship, 12 47 41           |                                     |                                 |                   |               |                        | h m s                                       |
| At Greenwich, by the Watch, 12 8 47 by Arnold, 11 57 50 by Kendal, 12 1 47 |                                     |                                 |                   |               |                        | h m s                                       |
| Difference of Meridians, 0 38 54   |                                     |                                 |                   |               |                        | 0 45 54                                     |
| Longitude of the Ship, 9° 43' 30" E  |                                     |                                 |                   |               |                        | 11° 28 30"                                  |

Observations

## Observations for finding the Longitude by the Time-keepers.

July 11, A. M.

| Time by<br>Arnold.                                  | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Arnold<br>too<br>flow. | Mean,<br>52' 31"   | Lat.<br>80° 22'   | Decl.<br>22 7 20  | Eq. Time,<br>4 <sup>h</sup> 56 |
|---|-------------------------------------|---------------------------------|-------------------|---------------|------------------------|--------------------|-------------------|-------------------|--------------------------------|
| h 3 32 22   | o 17 39                             | 20                              | h 4 19 49         | h 4 24 45     | 52 23                  |                    |                   |                   |                                |
| 3 38 48   | . . . .                             | 17 54 30                        | 4 26 31           | 4 31 27       | 52 39                  |                    |                   |                   |                                |
| At 3 <sup>h</sup> by Arnold, mean Time at the Ship, |                                     |                                 |                   |               |                        | h 3 52 31          | h 3 52 31         | h 3 52 31         | h 3 52 31                      |
| At Greenwich, by the Watch,                         |                                     |                                 |                   |               |                        | 3 16 23 by Arnold, | 3 3 21 by Kendal, | 3 3 21 by Kendal, | 3 3 21 by Kendal,              |
| Difference of Meridians,                            |                                     |                                 |                   |               |                        | o 36 8             | o 49 10           | o 43 12           | o 43 12                        |
| Longitude of the Ship,                              |                                     |                                 |                   |               |                        | 9° 2' 0" E         | 12° 17' 30"       | 10° 48' 0"        | 10° 48' 0"                     |

Observations

## Observations for finding the Longitude by the Time-keepers.

| July 12, P. M.   |                               |                           |                |            |                 | Correction for Error of Sextant, -4' 30" |             |
|--|-------------------------------|---------------------------|----------------|------------|-----------------|--|-------------|
| Time by the Watch.   | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. |  |             |
| h ' "  | ° ' "                         | ° ' "                     | h ' "          | h ' "      | ' "             |  |             |
| 7 26 25  | 16 5 0                        | 16 9 10                   | 8 15 9         | 8 20 18    | 53 53           | Lat. 80 4 0                              |             |
| 7 27 58  | 16 3 0                        | 19 7 10                   | 8 16 8         | 8 21 17    | 53 19           | Decl. 21 53 10                           |             |
| 7 28 44  | 16 2 15                       | 16 6 25                   | 8 16 30        | 8 21 39    | 52 55           | Eq. Time 5 19                            |             |
| 7 29 48  | 15 59 0                       | 16 3 10                   | 8 19 3         | 8 24 12    | 54 24           |  |             |
| At 12 <sup>h</sup> by the Watch, mean Time at the Ship, 12 53 38           |                               |                           |                |            |                 | h ' "                                    |             |
| At Greenwich, by the Watch, 12 10 1 by Arnold, 11 56 25 by Kendal, 12 2 45 |                               |                           |                |            |                 |  |             |
| Difference of Meridians, 0 43 37   |                               |                           |                |            |                 | 0 57 13                                  | 0 50 53     |
| Longitude of the Ship, 100 54' 15" E                                       |                               |                           |                |            |                 | 140 18' 15"                              | 120 43' 15" |

Observations

Observations for finding the Longitude by the Time-keepers.

| On Shore on an Island near Vogel Sang, Latitude 79° 50'                                       |                               |                                  |                                  |                               |                                    |                              |                        |                                |  |
|---|-------------------------------|----------------------------------|----------------------------------|-------------------------------|------------------------------------|------------------------------|------------------------|--------------------------------|--|
| Correction for Error of the Astronomical Quadrant, +7"  |                               |                                  |                                  |                               |                                    |                              |                        |                                |  |
| Day of the Month.   | Time by the Watch.            | Alt. of the Sun's lower Limb.    | Alt. of the Sun's Center.        | Apparent Time.                | Eq. Time.                          | Mean Time.                   | Watch too slow.        | Means.                         | Co. Decl.                                      |
| July 15 P.M.  | 3 30 53<br>3 32 57<br>3 34 22 | 25 21 50<br>25 17 0<br>25 13 20  | 25 35 29<br>25 30 39<br>25 26 59 | 4 16 31<br>4 18 23<br>4 19 52 | 5 + 29<br><br><br>5 + 31<br>5 + 35 | 4 22 0<br>4 23 52<br>4 25 21 | 51 7<br>50 55<br>50 59 | 51 0<br><br><br>51 5½          | 68 33 2<br><br><br>68 37 39<br>68 43 44        |
| 16 A.M. P.M.  | 3 9 50<br>5 55 25<br>5 59 0   | 15 39 47<br>18 55 12<br>18 46 10 | 15 52 6<br>19 8 8<br>18 59 6     | 3 54 59<br>6 41 1<br>6 44 25  | <br><br><br>5 + 40<br>5 + 41       | 4 0 30<br>6 46 36<br>6 50 0  | 50 40<br>51 11<br>51 0 | <br><br><br>68 54 0<br>68 55 0 | 68 37 39<br>68 43 44<br><br>68 54 0<br>68 55 0 |
| 17 P.M.<br>18 A.M.  | 5 31 45<br>8 28 3             | 19 46 40<br>13 8 20              | 19 59 43<br>13 20 0              | 6 17 17<br>8 52 53            | <br><br>5 + 41                     | 6 22 57<br>8 58 34           | 51 12<br>50 31         | <br><br>51 12                  | 68 54 0<br>68 55 0                             |
| July 16,  |                               |                                  |                                  |                               |                                    |                              |                        |                                |  |
| At 12 <sup>h</sup> by the Watch, Mean Time at the Island, 12 51 0 . . . 12 51 0 . . . 12 51 0 |                               |                                  |                                  |                               |                                    |                              |                        |                                |  |
| At Greenwich, by the Watch, 12 10 50 by Arnold, 11 55 20 by Kendal, 12 2 34                   |                               |                                  |                                  |                               |                                    |                              |                        |                                |  |
| Difference of Meridians 0 40 16   |                               |                                  |                                  |                               |                                    |                              |                        |                                |  |
| Longitude of the Island, 100 2' 30" E 0 55 40 130 55' 0" 120 6' 30"                           |                               |                                  |                                  |                               |                                    |                              |                        |                                |  |

Observations

## Observations for finding the Longitude by the Time-keepers.

July 26, P. M.

| Time by<br>the<br>Watch.   | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. | Lat.<br>Co. Decl. 70° 40' 40"<br>Eq. Time 6 <sup>h</sup> 42 <sup>m</sup> |
|--|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|--|
| h / "  | o / "                               | o / "                           | h / "             | h / "         | h / "                 | o / "  |
| 3 29 25  | 22 46 0                             | 22 55 40                        | 4 25 41           | 4 31 43       | 1 2 18                | 80 20 0  |
| 3 31 14  | 22 42 0                             | 22 51 40                        | 4 27 23           | 4 33 25       | 1 2 11                | 70 40 40   |
| 3 33 35  | 22 36 0                             | 22 45 40                        | 4 29 53           | 4 35 55       | 1 2 20                | Eq. Time 6 <sup>h</sup> 42 <sup>m</sup>                                  |
| 3 35 34  | 22 33 30                            | 22 43 10                        | 4 31 4            | 4 37 6        | 1 1 32                |  |
| 3 36 50  | 22 31 0                             | 22 40 40                        | 4 31 59           | 4 38 1        | 1 1 11                |  |
| 3 38 47  | 22 29 0                             | 22 38 40                        | 4 32 51           | 4 38 53       | 1 0 6                 |  |
|  |                                     |                                 | h / "             | h / "         | h / "                 | h / "  |
| At 12 <sup>h</sup> by the Watch, mean Time at the Ship, 1 2 16 . . . . . 1 2 16 . . . . . 1 2 16 |                                     |                                 |                   |               |                       |  |
| At Greenwich, by the Watch, 12 12 53 by Arnold, 11 51 10 by Kendal, 12 5 16                      |                                     |                                 |                   |               |                       |  |
| Difference of Meridians, 0 49 23   |                                     |                                 |                   |               |                       |  |
| Longitude of the Ship, 12° 20' 45" E 17° 46' 30" 14° 15' 0"                                      |                                     |                                 |                   |               |                       |  |

Observations



## Observations for finding the Longitude by the Time-keepers.

July 27, P. M.

| Time by<br>the<br>Watch.   | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. | Lat.<br>Co. Decl. 70 55 45<br>Eq. Time, 6 <sup>h</sup> 1 <sup>m</sup> |
|--|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|---|
| 5 51 16  | 16 15 0                             | 16 23 45                        | 6 58 31           | 7 4 32        | 1 13 16               | 80 23 0   |
| 5 53 22  | 16 10 30                            | 16 19 15                        | 7 0 24            | 7 6 25        | 1 13 3                | 70 55 45  |
| 5 55 26  | 16 5 45                             | 16 14 30                        | 7 2 24            | 7 8 25        | 1 12 59               | Mean 10 13 3  |
| 5 58 35  | 15 58 0                             | 16 6 45                         | 7 5 40            | 7 11 41       | 1 13 6                |   |
| 6 0 56   | 15 53 0                             | 16 1 45                         | 7 7 47            | 7 13 48       | 1 12 52               |   |
| At 12 <sup>h</sup> by the Watch, mean Time at the Ship, 1 13 3             |                                     |                                 |                   |               |                       | h / " 1 13 3  |
| At Greenwich, by the Watch, 12 13 5 by Arnold, 11 50 34 by Kendal, 12 5 27 |                                     |                                 |                   |               |                       | h / " 1 13 3  |
| Difference of Meridians, 0 59 58   |                                     |                                 |                   |               |                       | h / " 1 7 36  |
| Longitude of the Ship, 14° 59' 30" E                                       |                                     |                                 |                   |               |                       | 16° 54' 0"  |

Observations

# Observations for finding the Longitude by the Time-keepers.

July 28, P. M.

| Time by<br>the<br>Watch. | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. |                  |
|--------------------------|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|------------------|
| h m s                    | ° ' "                               | ° ' "                           | h m s             | h m s         | h m s                 | Lat. 80° 28' 10" |
| 5 22 34                  | 17 10 0                             | 17 18 50                        | 6 30 46           | 6 36 46       | 1 14 12               | Co. Dec. 71 9 10 |
| 5 28 58                  | 16 54 30                            | 17 3 20                         | 6 37 34           | 6 43 34       | 1 14 36               | Eq. Time, 6 40   |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, h m s 1 14 24  
 At Greenwich, by the Watch, 12 13 17 by Kendal, 12 5 48

Difference of Meridians,  
 Longitude of the Ship,

1 1 7  
 15° 16' 45" E 1 8 36  
 17° 9' 0"

Observations

Observations for finding the Longitude by the Time-keepers.

July 30, P. M.

| Time by<br>the<br>Watch. | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. |                   |
|--------------------------|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|-------------------|
| 3 14 40                  | 21 17 0                             | 21 26 30                        | 4 37 24           | 4 43 20       | 1 28 40               | Lat. 80 33 0      |
| 3 22 6                   | 20 59 0                             | 21 8 30                         | 4 45 11           | 4 50 57       | 1 28 51               | Co. Dec. 71 38 50 |
| 3 26 34                  | 20 48 45                            | 20 58 15                        | 4 49 21           | 3 55 17       | 1 28 43               | Eq. Time, 5+56    |
| 3 29 11                  | 20 41 30                            | 20 51 0                         | 4 52 21           | 4 58 17       | 1 29 6                |                   |
| 3 30 54                  | 20 37 30                            | 20 47 0                         | 4 54 11           | 4 59 57       | 1 29 3                | Mean              |
| 3 32 45                  | 20 33 30                            | 20 43 0                         | 4 55 33           | 5 1 29        | 1 28 44               | 1h 28' 54"        |
| 3 34 43                  | 20 28 0                             | 20 37 30                        | 4 57 39           | 5 3 55        | 1 29 12               |                   |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, 1 28 54 . . . 1 28 54  
 At Greenwich, by the Watch, 12 13 42 by Kendal, 12 6 40

Difference of Meridians,  
 Longitude of the Ship,

1 15 12  
 18° 48' 0" E  
 1 22 14  
 20° 33' 30"

Observations

## Observations for finding the Longitude by the Time-keepers.

| Day of the Month.   | Time by the Watch. | Alt. of the Sun's low-er Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. | Mean.     | Lat. 80 37 6<br>Co. Dec. 71 52 10<br>Eq. Time, 5+54 |
|---|--------------------|--------------------------------|---------------------------|----------------|------------|-----------------|-----------|---|
| July 31 P. M.   | h / ' / "          | o / ' / "                      | o / ' / "                 | h / ' / "      | h / ' / "  | h / ' / "       | h / ' / " |   |
|   | 3 53 30            | 19 26                          | 0 19 35 10                | 5 18 7         | 5 24       | 1 1 30 31       |           |   |
|   | 3 55 46            | 19 21                          | 0 19 30 40                | 5 19 55        | 5 25 49    | 1 30 3          |           |   |
|   | 3 58 30            | 19 17                          | 0 19 26 10                | 5 21 45        | 5 27 39    | 1 29 9          |           |   |
|   | 4 0 2              | 19 12                          | 0 19 21 40                | 5 23 29        | 5 29 23    | 1 29 21         |           |   |
|   | 4 0 50             | 19 8                           | 0 19 17 10                | 5 25 28        | 5 31 22    | 1 30 32         |           |   |
|   | 4 1 57             | 19 7                           | 0 19 16 10                | 5 26 29        | 5 32 23    | 1 30 26         |           |   |
|   | 4 2 50             | 19 6                           | 0 19 15 40                | 5 26 56        | 5 32 50    | 1 30 0          | 1 29 55   |   |
|   | 4 4 19             | 19 3                           | 0 19 12 10                | 5 27 31        | 5 33 25    | 1 29 6          |           |   |
|   | 4 5 36             | 18 59                          | 0 19 8 10                 | 5 29 9         | 5 35 3     | 1 29 27         |           |   |
|   | 4 6 35             | 18 56                          | 0 19 5 10                 | 5 30 23        | 5 36 17    | 1 29 42         |           |   |
|   | 4 7 26             | 18 52                          | 0 19 1 10                 | 5 32 1         | 5 37 55    | 1 30 29         |           |   |
|   | 4 8 14             | 18 50                          | 0 18 59 40                | 5 32 39        | 5 38 33    | 1 30 19         |           |   |
|   | 4 9 23             | 18 49                          | 0 18 58 10                | 5 33 15        | 5 39 9     | 1 29 46         |           |   |
| At 12 <sup>h</sup> by the Watch, mean Time at the Ship, 12 <sup>h</sup> 29' 55" |                    |                                |                           |                |            |                 |           | 12 29' 55"  |
| At Greenwich, by the Watch, 12 13 54 by Kendal, 12 16 52                        |                    |                                |                           |                |            |                 |           | 12 13 54 by Kendal, 12 16 52                        |
| Difference of Meridians, 1 10 1   |                    |                                |                           |                |            |                 |           | 1 10 1  |
| Longitude of the Ship, 19° 0' 15" E   |                    |                                |                           |                |            |                 |           | 19° 0' 15" E  |

Observations

| Observations for finding the Longitude by the Time-keepers.        |                    |                               |                           |                |            |                 |           |           |          |
|--|--------------------|-------------------------------|---------------------------|----------------|------------|-----------------|-----------|-----------|----------|
| At Smeerenberg, Lat. 79° 44'                                       |                    |                               |                           |                |            |                 |           |           |          |
| By the Astronomical Quadrant, Correction for Error of Quadrant—32" |                    |                               |                           |                |            |                 |           |           |          |
| Day of the Month.  | Time by the Watch. | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. | Eq. Time. | Co. Decl. |          |
|  | h / "              | o / "                         | o / "                     | h / "          | h / "      | h / "           | ' "       | ' "       | o / ' "  |
| Aug. 14.<br>P.M.   | 5 38 30            | 12 24 0                       | 12 35 0                   | 6 30 21        | 6 34 31    | 56 1            | 4 10      | 75 50 30  |          |
|  | 5 47 37            | 12 0 0                        | 12 11 0                   | 6 39 31        | 6 43 41    | 56 4            |           |           |          |
|  | 6 1 15             | 11 24 0                       | 11 34 40                  | 6 53 24        | 6 57 34    | 56 19           |           |           |          |
|  | 6 2 39             | 11 21 0                       | 11 31 40                  | 6 54 59        | 6 59 9     | 56 30           |           |           |          |
|  | 6 5 2              | 11 15 0                       | 11 25 40                  | 6 56 54        | 7 1 4      | 56 2            |           |           | 75 50 50 |
|  | 6 6 8              | 11 12 0                       | 11 22 40                  | 6 58 4         | 7 2 14     | 56 6            |           |           |          |
|  | 6 7 24             | 11 9 0                        | 11 19 40                  | 6 59 15        | 7 3 25     | 56 1            |           |           |          |
|  | 6 8 39             | 11 6 0                        | 11 16 40                  | 7 0 0          | 7 4 9      | 55 30           | 4 9       |           |          |
|  | 6 9 45             | 11 3 0                        | 11 13 40                  | 7 1 31         | 7 5 40     | 55 55           |           |           |          |
|  | 6 11 3             | 11 0 0                        | 11 10 40                  | 7 2 42         | 7 6 51     | 55 48           |           |           |          |
|  | 6 15 44            | 10 48 0                       | 10 58 30                  | 7 7 23         | 7 11 32    | 55 48           |           |           | 75 51 0  |
|  |                    |                               |                           |                |            |                 |           |           |          |

Observations

## Observations for finding the Longitude by the Time-keepers.

| Day of<br>the<br>Month. | Time by<br>the<br>Watch. |    | Alt. of the<br>Sun's lower<br>Limb. |    | Alt. of<br>the Sun's<br>Center. |    | Apparent<br>Time. |    | Mean<br>Time. |    | Watch<br>too<br>slow. |    | Eq. Time. |   | Co. Decl. |    |
|-------------------------|--------------------------|----|-------------------------------------|----|---------------------------------|----|-------------------|----|---------------|----|-----------------------|----|-----------|---|-----------|----|
|                         | h                        | m  | °                                   | '  | °                               | '  | h                 | m  | h             | m  | h                     | m  | h         | m | °         | '  |
| Aug. 14.<br>P. M.       | 6                        | 16 | 41                                  | 0  | 10                              | 55 | 30                | 7  | 8             | 41 |                       |    |           |   |           |    |
|                         | 6                        | 17 | 51                                  | 0  | 10                              | 52 | 30                | 7  | 9             | 54 |                       |    |           |   |           |    |
|                         | 6                        | 19 | 10                                  | 0  | 10                              | 49 | 20                | 7  | 11            | 8  |                       |    |           |   |           |    |
|                         | 6                        | 20 | 22                                  | 0  | 10                              | 46 | 20                | 7  | 12            | 20 |                       |    |           |   |           |    |
| 15, A. M.               | 4                        | 56 | 57                                  | 13 | 6                               | 0  | 13                | 17 | 20            | 5  | 48                    | 53 |           |   |           |    |
|                         | 4                        | 59 | 20                                  | 13 | 12                              | 0  | 13                | 23 | 20            | 5  | 51                    | 9  |           |   |           |    |
|                         | 5                        | 2  | 26                                  | 13 | 21                              | 0  | 13                | 32 | 20            | 5  | 54                    | 32 |           |   |           |    |
|                         | 5                        | 3  | 35                                  | 13 | 24                              | 0  | 13                | 35 | 20            | 5  | 55                    | 43 |           |   |           |    |
|                         | 5                        | 4  | 46                                  | 13 | 27                              | 0  | 13                | 38 | 20            | 5  | 56                    | 55 |           |   |           |    |
|                         | 5                        | 7  | 6                                   | 13 | 33                              | 0  | 13                | 44 | 20            | 5  | 59                    | 5  |           |   |           |    |
|                         | 5                        | 8  | 19                                  | 13 | 36                              | 0  | 13                | 47 | 20            | 6  | 0                     | 12 |           |   |           |    |
|                         | 5                        | 9  | 12                                  | 13 | 39                              | 0  | 13                | 50 | 30            | 6  | 1                     | 24 |           |   |           |    |
|                         | 5                        | 10 | 23                                  | 13 | 42                              | 0  | 13                | 53 | 30            | 6  | 2                     | 31 |           |   |           |    |
|                         | 5                        | 11 | 34                                  | 13 | 45                              | 0  | 13                | 56 | 30            | 6  | 3                     | 41 |           |   |           |    |
|                         |                          |    |                                     |    |                                 |    |                   |    |               |    |                       | 3  | 57        |   | 75        | 59 |
|                         |                          |    |                                     |    |                                 |    |                   |    |               |    |                       |    |           |   | 75        | 59 |

Observations

| Observations for finding the Longitude by the Time-keepers. |                          |    |                                     |    |                                 |   |                   |    |               |                       |           |           |   |    |    |  |  |  |  |
|---|--------------------------|----|-------------------------------------|----|---------------------------------|---|-------------------|----|---------------|-----------------------|-----------|-----------|---|----|----|--|--|--|--|
| Day-of<br>the<br>Month.                                     | Time by<br>the<br>Watch. |    | Alt. of the<br>Sun's lower<br>Limb. |    | Alt. of<br>the Sun's<br>Center. |   | Apparent<br>Time. |    | Mean<br>Time. | Watch<br>too<br>slow. | Eq. Time. | Co. Decl. |   |    |    |  |  |  |  |
|   | h                        | m  | °                                   | '  | "                               | ° | '                 | "  | h             | m                     | s         | °         |   |    |    |  |  |  |  |
| Aug. 15.<br>A. M.   | 5                        | 12 | 43                                  | 13 | 48                              | 0 | 13                | 59 | 30            | 6                     | 4         | 49        | 6 | 8  | 46 |  |  |  |  |
|   | 5                        | 13 | 49                                  | 13 | 51                              | 0 | 14                | 2  | 30            | 6                     | 5         | 56        | 6 | 9  | 53 |  |  |  |  |
|   | 5                        | 20 | 42                                  | 14 | 9                               | 0 | 14                | 20 | 40            | 6                     | 12        | 44        | 6 | 16 | 41 |  |  |  |  |
|   | 5                        | 22 | 56                                  | 14 | 15                              | 0 | 14                | 26 | 40            | 6                     | 14        | 59        | 6 | 18 | 56 |  |  |  |  |
|   | 5                        | 24 | 2                                   | 14 | 18                              | 0 | 14                | 29 | 40            | 6                     | 16        | 5         | 6 | 20 | 2  |  |  |  |  |
| 18, A. M.   | 5                        | 27 | 25                                  | 14 | 27                              | 0 | 14                | 38 | 40            | 6                     | 19        | 28        | 6 | 23 | 25 |  |  |  |  |
|   | 4                        | 57 | 8                                   | 12 | 15                              | 0 | 12                | 26 | 0             | 5                     | 50        | 51        | 5 | 34 | 19 |  |  |  |  |
|   | 5                        | 0  | 31                                  | 12 | 24                              | 0 | 12                | 35 | 0             | 5                     | 54        | 13        | 5 | 57 | 41 |  |  |  |  |
|   | 5                        | 1  | 46                                  | 12 | 27                              | 0 | 12                | 38 | 0             | 5                     | 55        | 21        | 5 | 58 | 49 |  |  |  |  |
|   | 5                        | 2  | 51                                  | 12 | 30                              | 0 | 12                | 41 | 0             | 5                     | 56        | 29        | 5 | 59 | 57 |  |  |  |  |
|   | 5                        | 3  | 57                                  | 12 | 33                              | 0 | 12                | 44 | 0             | 5                     | 57        | 35        | 6 | 1  | 3  |  |  |  |  |
|   | 5                        | 6  | 11                                  | 12 | 39                              | 0 | 12                | 50 | 10            | 5                     | 59        | 51        | 6 | 3  | 19 |  |  |  |  |
|   | 5                        | 7  | 20                                  | 12 | 42                              | 0 | 12                | 53 | 10            | 6                     | 1         | 2         | 6 | 4  | 30 |  |  |  |  |
|   | 5                        | 11 | 52                                  | 12 | 54                              | 0 | 13                | 5  | 10            | 6                     | 5         | 35        | 6 | 9  | 3  |  |  |  |  |
|   |                          |    |                                     |    |                                 |   |                   |    |               |                       |           |           |   |    |    |  |  |  |  |

Observations

## Observations for finding the Longitude by the Time-keepers.

| Day of<br>the<br>Month. | Time by<br>the<br>Watch. | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. | Eq. Time, | Co. Decl. |
|-------------------------|--------------------------|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|-----------|-----------|
|                         | h m s                    | ° ' "                               | ° ' "                           | h m s             | h m s         | h m s                 | m s       | ° ' "     |
| Aug. 18,<br>A.M.        | 5 13 6                   | 12 57 0                             | 13 8 10                         | 6 6 42            | 6 10 10       | 57 4                  |           |           |
|                         | 5 15 15                  | 13 3 0                              | 13 14 20                        | 6 9 0             | 6 12 28       | 57 13                 |           |           |
|                         | 5 16 32                  | 13 6 0                              | 13 17 20                        | 6 10 8            | 6 13 36       | 57 4                  |           |           |
|                         | 5 17 39                  | 13 9 0                              | 13 20 20                        | 6 11 15           | 6 14 43       | 57 4                  |           |           |
|                         | 5 19 50                  | 13 13 0                             | 13 26 20                        | 6 13 29           | 6 16 57       | 57 7                  |           |           |
|                         | 5 20 55                  | 13 18 0                             | 13 29 20                        | 6 14 37           | 6 18 5        | 57 10                 |           |           |
|                         | 5 22 5                   | 13 21 0                             | 13 32 20                        | 6 15 48           | 6 19 16       | 57 12                 |           | 76 57 10  |
|                         | 5 24 24                  | 13 27 0                             | 13 38 20                        | 6 18 3            | 6 21 31       | 57 7                  |           |           |
|                         | 5 25 35                  | 13 30 0                             | 13 41 20                        | 6 19 11           | 6 22 39       | 57 4                  |           |           |
|                         | 5 27 43                  | 13 26 0                             | 13 47 30                        | 6 21 29           | 6 24 37       | 57 14                 |           |           |
|                         | 5 28 55                  | 13 39 0                             | 13 50 30                        | 6 22 36           | 6 26 4        | 57 9                  |           |           |
|                         | 5 37 58                  | 14 3 0                              | 14 14 40                        | 6 31 44           | 6 35 11       | 57 13                 | 31-27     | 76 57 20  |
|                         | 5 41 23                  | 14 12 0                             | 14 23 40                        | 6 35 44           | 6 39 11       | 57 48                 |           |           |
|                         | 5 42 28                  | 14 15 0                             | 14 26 40                        | 6 36 19           | 6 39 46       | 57 18                 |           |           |

Observations



## Observations for finding the Longitude by the Time-keepers.

| Day of the Month. | Time by the Watch. | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. | Eq. Time. | Co. Decl. |
|-------------------|--------------------|-------------------------------|---------------------------|----------------|------------|-----------------|-----------|-----------|
| Aug. 18, A.M.     | h m s              | ° ' "                         | ° ' "                     | h m s          | h m s      | ' "             | ' "       | ° ' "     |
|                   | 5 43 39            | 14 18 0                       | 14 29 40                  | 6 37 27        | 6 40 54    | 57 15           |           | 6 57 30   |
|                   | 5 45 49            | 14 24 0                       | 14 35 40                  | 6 39 1         | 6 42 28    | 56 39           |           |           |
|                   | 5 47 4             | 14 27 0                       | 14 38 40                  | 6 40 49        | 6 44 16    | 57 12           |           |           |
|                   | 5 48 13            | 14 30 0                       | 14 41 40                  | 6 42 1         | 6 45 28    | 57 15           |           |           |
|                   | 5 49 21            | 14 33 0                       | 14 44 40                  | 6 43 9         | 6 46 36    | 57 15           |           | 76 57 40  |
|                   | 5 59 39            | 15 0 0                        | 15 11 50                  | 6 53 27        | 6 56 54    | 57 15           |           |           |
|                   | 6 0 53             | 15 3 0                        | 15 14 50                  | 6 54 37        | 6 58 4     | 57 11           |           |           |
|                   | 6 1 58             | 15 6 0                        | 15 17 50                  | 6 55 45        | 6 59 12    | 57 14           |           |           |
|                   | 6 3 8              | 15 9 0                        | 15 20 50                  | 6 56 53        | 7 0 20     | 57 12           |           |           |
|                   | 6 4 17             | 15 12 0                       | 15 23 50                  | 6 58 3         | 7 1 30     | 57 13           |           |           |
|                   | 6 5 29             | 15 15 0                       | 15 26 50                  | 6 59 12        | 7 2 39     | 57 10           |           | 76 57 50  |
|                   | 6 6 36             | 15 18 0                       | 15 29 50                  | 7 0 24         | 7 3 51     | 57 15           |           |           |
|                   | 6 7 42             | 15 21 0                       | 15 32 50                  | 7 1 33         | 7 5 0      | 57 18           |           |           |
|                   | 6 11 19            | 15 30 0                       | 15 41 50                  | 7 5 1          | 7 8 28     | 57 9            |           |           |

Observations

## Observations for finding the Longitude by the Time-keepers.

| Day of the Month. | Time by the Watch. | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. | Eq. Time | Co. Decl. |
|-------------------|--------------------|-------------------------------|---------------------------|----------------|------------|-----------------|----------|-----------|
| Aug. 18<br>A. M.  | 6 13 32            | 15 36 0                       | 15 47 50                  | 7 7 19         | 7 10 46    | 57 14           |          |           |
|                   | 6 14 49            | 15 39 0                       | 15 51 0                   | 7 8 33         | 7 12 0     | 57 11           |          |           |
|                   | 6 16 1             | 15 42 0                       | 15 54 0                   | 7 9 43         | 7 13 10    | 57 9            |          |           |
| 18, P. M.         | 5 10 49            | 12 18 0                       | 12 29 0                   | 6 4 21         | 6 7 42     | 56 53           | 3 21     | 77 6 50   |
|                   | 5 12 55            | 12 12 0                       | 12 23 0                   | 6 6 35         | 6 9 56     | 57 1            |          |           |
|                   | 5 14 6             | 12 9 0                        | 12 20 0                   | 6 7 43         | 6 11 4     | 56 58           |          |           |
|                   | 5 15 14            | 12 6 0                        | 12 17 0                   | 6 8 51         | 6 12 12    | 56 58           |          |           |
|                   | 5 16 16            | 12 3 0                        | 12 14 0                   | 6 9 58         | 6 13 19    | 57 3            |          |           |
|                   | 5 17 22            | 12 0 0                        | 12 11 0                   | 6 11 5         | 6 14 26    | 57 4            |          |           |
|                   | 5 18 40            | 11 57 0                       | 12 8 0                    | 6 12 13        | 6 15 34    | 56 54           |          |           |
|                   | 5 19 35            | 11 54 0                       | 12 5 0                    | 6 13 21        | 6 16 42    | 57 7            |          |           |
|                   | 5 20 48            | 11 51 0                       | 12 1 50                   | 6 14 27        | 6 17 48    | 57 0            |          |           |
|                   | 5 21 51            | 11 48 0                       | 11 58 50                  | 6 15 40        | 6 19 1     | 57 10           |          |           |

Observations



Observations for finding the Longitude by the Time-keepers.

August 31, P. M.

| Time by the Watch                                       | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. |                    |
|---|-------------------------------|---------------------------|----------------|------------|-----------------|--------------------|
| h ' "   | o ' "                         | o ' "                     | h ' "          | h ' "      | h ' "           | • ' "              |
| 6 1 54  | 4 35 0                        | 4 36 10                   | 6 35 43        | 6 35 31    | 33 37           | Lat. 68 46 0       |
| 6 4 31  | 4 23 0                        | 4 23 50                   | 6 38 1         | 6 37 49    | 33 18           | Co. Decl. 81 37 10 |
| 6 6 20  | 4 10 0                        | 4 10 30                   | 6 40 33        | 6 40 21    | 34 1            | Eq. Time, 0-12     |
| 6 7 40  | 4 2 0                         | 4 2 10                    | 6 42 7         | 6 41 55    | 34 15           |                    |
| 6 10 1  | 3 51 0                        | 3 50 50                   | 6 44 16        | 6 44 4     | 34 3            |                    |
| 6 11 33   | 3 44 0                        | 3 43 30                   | 6 45 39        | 6 45 27    | 33 54           |                    |
|   |                               |                           |                |            |                 | h ' "              |
| At 12° by the Watch, mean Time at the Ship, 12 33 51    |                               |                           |                |            |                 | 12 33 51           |
| At Greenwich, by the Watch, 12 20 15 by Kendal, 12 7 57 |                               |                           |                |            |                 | 12 7 57            |
|   |                               |                           |                |            |                 | Mean 33' 51"       |

Difference of Meridians,  
Longitude of the Ship,

0 13 36  
3° 24' 0" E

Observations

## Observations for finding the Longitude by the Time-keepers.

Sept. 3, P. M.

| Time by the Watch | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. | Lat. Co. Decl. Eq. Time     |
|-------------------|-------------------------------|---------------------------|----------------|------------|-----------------|-----------------------------|
| 5 14 0            | 7 50 0                        | 7 55 30                   | 5 46 31        | 5 45 25    | 31 25           | 0 1 0                       |
| 5 16 30           | 7 30 0                        | 7 35 20                   | 5 48 52        | 5 47 46    | 31 16           | 65 31 0                     |
| 5 17 7            | 7 24 30                       | 7 29 30                   | 5 49 34        | 5 48 28    | 31 21           | 82 41 20                    |
| 5 18 20           | 7 20 0                        | 7 25 0                    | 5 50 5         | 5 48 59    | 30 39           | 1—6                         |
| 5 18 55           | 7 16 30                       | 7 21 30                   | 5 50 30        | 5 49 24    | 30 29           |                             |
| 5 19 40           | 7 13 0                        | 7 18 0                    | 5 50 55        | 5 49 49    | 30 9            |                             |
| 5 20 50           | 7 4 30                        | 7 9 20                    | 5 52 16        | 5 51 10    | 30 20           |                             |
| 5 21 50           | 6 58 0                        | 7 2 50                    | 5 52 43        | 5 51 37    | 29 47           |                             |
|                   |                               |                           |                |            | h               |                             |
|                   |                               |                           |                |            | Mean 30' 41"    |                             |
|                   |                               |                           |                |            |                 | h                           |
|                   |                               |                           |                |            |                 | 12 30 41                    |
|                   |                               |                           |                |            |                 | 12 30 41                    |
|                   |                               |                           |                |            |                 | 12 20 51 by Kendal, 12 8 38 |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, 12 30 41  
 At Greenwich, by the Watch, 12 20 51 by Kendal, 12 8 38

Difference of Meridians,  
 Longitude of the Ship,

0 9 50  
 2° 27' 30" E

0 22 3  
 5° 30' 45"

Observations

Observations for finding the Longitude by the Time-keepers.

Sept. 6, A. M.

| Time by<br>the<br>Watch. | Alt. of<br>the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. | Lat.<br>Co. Decl. 83 41 30<br>Eq. Time 1-58 |
|--------------------------|--|---------------------------------|-------------------|---------------|-----------------------|---|
| h 8 56 25                | 26 50 0                                | 27 0 10                         | 9 22 57           | 9 20 59       | 24 34                 | 62° 50' 0"                                  |
| h 8 58 27                | 26 58 0                                | 27 8 10                         | 9 24 36           | 9 22 38       | 24 11                 | Co. Decl. 83 41 30<br>Eq. Time 1-58         |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, 12 24 22 . . . 12 24 22  
At Greenwich, by the Watch, 12 21 28 by Kendal, 12 9 22

Difference of Meridians,  
Longitude of the Ship,

0 2 54  
0° 43' 30" E

Observations

## Observations for finding the Longitude by the Moon.

Sept. 6, P. M.

| Time by the Watch. | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. |              |                  |
|--------------------|-------------------------------|---------------------------|----------------|------------|-----------------|--------------|------------------|
| h m                | ° ' "                         | ° ' "                     | h m            | h m        | h m             | ° ' "        | ° ' "            |
| 4 44 14            | 10 35 0                       | 10 42 10                  | 5 15 17        | 5 13 14    | 29 0            |              | Lat. 61 57 0     |
| 4 45 54            | 10 26 0                       | 10 33 0                   | 5 16 35        | 5 14 32    | 28 38           |              | Co. Dec. 83 49 0 |
| 4 47 29            | 10 13 0                       | 10 20 0                   | 5 18 27        | 5 16 24    | 28 55           | Mean 28' 49" | Eq. Time, 2-3    |
| 4 48 59            | 10 4 0                        | 10 10 50                  | 5 19 45        | 5 17 42    | 28 43           |              |                  |
| 4 50 0             | 9 56 0                        | 10 1 50                   | 5 21 2         | 5 18 59    | 28 59           |              |                  |
| 4 52 36            | 9 39 0                        | 9 45 40                   | 5 23 20        | 5 21 17    | 28 41           |              |                  |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, 12 28 49 . . . 12 28 49  
 At Greenwich, by the Watch, 12 21 28 by Kendal, 12 9 22

Difference of Meridians,  
 Longitude of the Ship,

0 7 21  
 1° 50' 15" E

0 19 27  
 4° 51' 45"

Observations

Observations for finding the Longitude by the Time-keepers.

Sept. 14, P. M.

| Time by the Watch. | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Apparent Time. | Mean Time. | Watch too slow. |                   |
|--------------------|-------------------------------|---------------------------|----------------|------------|-----------------|-------------------|
| h m s              | ° ' "                         | ° ' "                     | h m s          | h m s      | h m s           |                   |
| 2 54 41            | 22 39 0                       | 22 48 50                  | 3 30 55        | 3 26 31    | 27              |                   |
| 2 55 40            | 22 36 0                       | 22 45 50                  | 3 31 21        | 3 26 34    | 54              |                   |
| 2 56 34            | 22 29 0                       | 22 38 50                  | 3 32 17        | 3 27 30    | 30              |                   |
| 2 57 41            | 22 18 0                       | 22 27 50                  | 3 33 48        | 3 29 13    | 20              |                   |
| 2 58 52            | 22 10 0                       | 22 19 50                  | 3 34 52        | 3 30 53    | 13              |                   |
| 3 22 24            | 21 43 0                       | 22 52 50                  | 3 38 31        | 3 33 44    | 31              |                   |
|                    |                               |                           |                |            |                 | h m s             |
|                    |                               |                           |                |            |                 | Lat. 55 32 0      |
|                    |                               |                           |                |            |                 | Co. Decl. 86 50 0 |
|                    |                               |                           |                |            |                 | Eq. Time 4-47     |
|                    |                               |                           |                |            |                 | Mean 31' 12"      |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, 12 31 12 . . . 12 31 12  
 At Greenwich, by the Watch, 12 23 6 by Kendal, 12 10 31

Difference of Meridians, 0 8 6  
 Longitude of the Ship, 2° 1' 30"E 0 20 41  
 5° 10' 15"

Observations



## Observations for finding the Longitude by the Time-keepers.

Sept. 25, A. M. in Hofely Bay.

| Time by<br>the<br>Watch. | Alt. of the<br>Sun's lower<br>Limb. | Alt. of<br>the Sun's<br>Center. | Apparent<br>Time. | Mean<br>Time. | Watch<br>too<br>slow. | Lat.<br>N. Pol. dist.<br>Eq. Time, |
|--------------------------|-------------------------------------|---------------------------------|-------------------|---------------|-----------------------|------------------------------------|
| h / "                    | o / "                               | o / "                           | h / "             | h / "         | h / "                 | 52° 6' 0"                          |
| 9 22 47                  | 30 54 0                             | 31 4 40                         | 9 58 47           | 9 50 17       | 28 30                 | 91 1 10                            |
| 9 24 17                  | 31 5 0                              | 31 15 40                        | 10 0 49           | 9 52 19       | 28 2                  | 8—30                               |
|                          |                                     |                                 |                   | Mean, 28' 16" |                       |                                    |

At 12<sup>h</sup> by the Watch, mean Time at the Ship, 12 28 16 . . . h / " 12 28 16  
 At Greenwich, by the Watch, 12 25 21 by Kendal, 12 14 37 . . . h / " 12 14 37

Difference of Meridians,  
 Longitude of the Ship,

o 2 55  
 0° 43' 45" E  
 o 13 39  
 3° 24' 45"

Observations

## Observations for finding the Longitude by the Moon.

June 13, A. M.

| Time by<br>Arnold. | Alt. of the<br>Sun's low-<br>er Limb. | Alt. of the<br>Moon's low-<br>er Limb. | Dist. of Sun<br>and Moon's<br>nearest limbs | True Dist.<br>of the<br>Centers. | Apparent<br>Time at<br>Greenwich. | Apparent<br>Time at<br>the Ship. | Diff. of<br>Meridi-<br>ans. | Longitude<br>of the Ship. |
|--------------------|---------------------------------------|--|---|----------------------------------|-----------------------------------|----------------------------------|-----------------------------|---------------------------|
| h m s              | ° ' "                                 | ° ' "                                  | ° ' "                                       | ° ' "                            | h m s                             | h m s                            | ' "                         | ° ' "                     |
| 10 16 17           | 49 39                                 | 0 21 17                                | 0 74 37                                     | 0 74 30 53                       | 22 17 17                          | 22 20 37                         | 3 20                        | 0 50 0 E                  |
| 10 20 17           | 49 55                                 | 0 20 54                                | 0 74 37                                     | 0 74 30 39                       | 22 17 47                          | 22 24 8                          | 6 21                        | 1 35 15                   |
| 10 25 35           | 50 18                                 | 0 20 20                                | 0 74 37                                     | 0 74 30 22                       | 22 18 23                          | 22 29 27                         | 11 4                        | 2 46 0                    |
|                    |                                       |  |   |                                  |                                   |                                  | Mean                        | 1 43 45                   |

June 14, A. M.

Correction for Error of the Sextant, —3' 46"

| Time by<br>Arnold. | Alt. of the<br>Sun's low-<br>er Limb. | Alt. of the<br>Moon's low-<br>er Limb. | Dist. of Sun<br>and Moon's<br>nearest limbs | True Dist.<br>of the<br>Centers. | Apparent<br>Time at<br>Greenwich. | Apparent<br>Time at<br>the Ship. | Diff. of<br>Meridi-<br>ans. | Longitude<br>of the Ship. |
|--------------------|---------------------------------------|--|---|----------------------------------|-----------------------------------|----------------------------------|-----------------------------|---------------------------|
| h m s              | ° ' "                                 | ° ' "                                  | ° ' "                                       | ° ' "                            | h m s                             | h m s                            | ' "                         | ° ' "                     |
| 9 44 32            | 45 57                                 | 0 30 42                                | 0 63 47 30                                  | 0 63 45 45                       | 21 52 12                          | 21 43 56                         | 8 16                        | 2 4 0 W                   |
| 9 48 41            | 46 21                                 | 0 30 26                                | 0 63 44                                     | 0 63 41 54                       | 22 0 42                           | 21 48 20                         | 12 22                       | 3 5 30                    |
| 9 52 53            | 46 41                                 | 0 30 10                                | 0 63 41 30                                  | 0 63 39 3                        | 22 6 59                           | 21 52 4                          | 14 55                       | 3 43 45                   |
|                    |                                       |  |   |                                  |                                   |                                  | Mean                        | 2 57 45 W                 |

Observations

## Observations for finding the Longitude by the Moon.

June 15, A. M.

| Time by<br>Arnold. | Alt. of the<br>Sun's low-<br>er Limb. | Alt. of the<br>Moon's low-<br>er Limb. | Diff. of Sun<br>and Moon's<br>nearest limbs | True Diff.<br>of the<br>Centers. | Apparent<br>Time at<br>Greenwich. | Apparent<br>Time at<br>the Ship. | Diff. of<br>Meridi-<br>ans. | Longitude<br>of the Ship. |
|--------------------|---------------------------------------|--|---|----------------------------------|-----------------------------------|----------------------------------|-----------------------------|---------------------------|
| h / "              | o / "                                 | o / "                                  | o / "                                       | o / "                            | h / "                             | h / "                            | / "                         | o / "                     |
| 10 30 36           | 49 50                                 | 34 20                                  | 52 35                                       | 52 37 41                         | 22 32 3                           | 22 32 10                         | 0 9                         | 0 2 15 E                  |
| 10 32 4            | 49 54                                 | 34 20                                  | 52 34 45                                    | 52 37 23                         | 22 34 56                          | 22 33 40                         | 1 16                        | 0 19 30 W                 |
| 10 34 33           | 50 3                                  | 34 10                                  | 52 32                                       | 52 34 26                         | 22 39 17                          | 22 36 9                          | 3 8                         | 0 47 0                    |
| 10 36 23           | 50 9                                  | 34 4                                   | 52 32                                       | 52 34 18                         | 22 39 35                          | 22 37 59                         | 1 36                        | 0 24 0                    |
| 10 39 54           | 50 18                                 | 33 51                                  | 52 31 15                                    | 52 33 20                         | 22 41 14                          | 22 41 30                         | 0 14                        | 0 3 30                    |
| 10 41 34           | 50 28                                 | 33 40                                  | 52 31                                       | 52 32 51                         | 22 42 47                          | 22 42 10                         | 0 37                        | 0 9 15                    |
|                    |                                       |  |   |                                  |                                   |                                  | Mean                        | 0 17 0 W                  |

June 25, P. M.

| Time by<br>Arnold. | Alt. of the<br>Sun's low-<br>er Limb. | Alt. of the<br>Moon's low-<br>er Limb. | Diff. of Sun<br>and Moon's<br>nearest limbs | True Diff.<br>of the<br>Centers. | Apparent<br>Time at<br>Greenwich. | Apparent<br>Time at<br>the Ship. | Diff. of<br>Meridi-<br>ans. | Longitude<br>of the Ship. |
|--------------------|---------------------------------------|--|---|----------------------------------|-----------------------------------|----------------------------------|-----------------------------|---------------------------|
| h / "              | o / "                                 | o / "                                  | o / "                                       | o / "                            | h / "                             | h / "                            | / "                         | o / "                     |
| 7 49 2             | 12 54                                 | 11 40                                  | 65 58                                       | 66 21 55                         | 7 30 23                           | 8 22 13                          | 51 50                       | 12 57 30 E                |

Observations

## Observations for finding the Longitude by the Moon.

June 26, P. M.

| Time by the Watch. | Alt. of the Sun's lower Limb. | Alt. of the Sun's Center. | Alt. of Moon's lower Limb. | Alt. of Moon's Center. | Dist. of Sun and Moon's nearest limbs | True Diff. of the Centers. | Apparent Time at Greenwich. | Apparent Time at the Ship. | Diff. of Meridians. | Longitude of the Ship. |
|--------------------|-------------------------------|---------------------------|----------------------------|------------------------|---------------------------------------|----------------------------|-----------------------------|----------------------------|---------------------|------------------------|
| h m s              | ° ' "                         | ° ' "                     | ° ' "                      | ° ' "                  | ° ' "                                 | ° ' "                      | h m s                       | h m s                      | ° ' "               | ° ' "                  |
| 1 24 25            | 36 18                         | 12 51                     | 12 51                      | 12 51                  | 75 39 30                              | 75 41 30                   | 1 25 1                      | 2 4 15 30                  | 1 39 50             | 9 57 30 E              |
| 1 28 14            | 35 58                         | 12 50                     | 12 50                      | 12 50                  | 75 43 0                               | 75 45 13                   | 1 32 5                      | 2 11 55 30                 | 1 39 50             | 9 57 30                |
| 1 29 48            | 35 58                         | 12 50                     | 12 50                      | 12 50                  | 75 43 0                               | 75 45 13                   | 1 32 5                      | 2 11 55 30                 | 1 39 50             | 9 57 30                |
| 1 32 5             | 36 1                          | 12 50                     | 12 50                      | 12 50                  | 75 43 0                               | 75 45 13                   | 1 32 5                      | 2 11 55 30                 | 1 39 50             | 9 57 30                |
| 1 34 3             | 36 1                          | 12 50                     | 12 50                      | 12 50                  | 75 43 0                               | 75 45 13                   | 1 32 5                      | 2 11 55 30                 | 1 39 50             | 9 57 30                |
| 1 36 9             | 35 41                         | 12 50                     | 12 50                      | 12 50                  | 75 43 0                               | 75 45 13                   | 1 32 5                      | 2 11 55 30                 | 1 39 50             | 9 57 30                |

Observations

Observations for finding the Longitude by the Moon.

July 11, A. M.

Arnold too slow for Apparent Time 47' 35". Correction for Error of the Sextant, +4' 24"

| Time by<br>Arnold. | Alt. of the Sun's<br>lower<br>Limb. | Alt. of the<br>Moon's<br>lower Limb. | Dist. of Sun<br>and Moon's<br>nearest limbs | True Dist.<br>of the<br>Centers. | Apparent<br>Time at<br>Greenwich. | Apparent<br>Time at<br>the Ship. | Diff. of<br>Meridi-<br>ans. | Longitude<br>of the Ship. |
|--------------------|-------------------------------------|--------------------------------------|---|----------------------------------|-----------------------------------|----------------------------------|-----------------------------|---------------------------|
| 3 28 15            | 0 17 20 10                          | 0 13 6 0                             | 0 95 44 0                                   | 0 96 3 35                        | h 15 32 47                        | h 16 15 50 45                    | 1 10 45 45                  | 0 10 45 45                |
| 3 30 12            | 17 25                               |                                      |   |                                  |                                   |                                  |                             |                           |
| 3 32 22            |                                     | 17 39 20                             | 0 95 40 0                                   | 0 95 59 20                       | 15 41 58                          | 16 19 57 37 59                   | 3 9 29 45                   | 9 29 45                   |
| 3 34 7             | 17 34                               |                                      |   |                                  |                                   |                                  |                             |                           |
| 3 38 48            |                                     | 17 54 30                             | 0 95 36 0                                   | 0 95 55 8                        | 15 51 3                           | 16 26 23 35 20                   | 8 50 0                      | 8 50 0                    |
| 3 40 24            | 17 50                               |                                      |   |                                  |                                   |                                  | Mean, 9 42 0 E              | 9 42 0 E                  |

Observations

## Observations for finding the Longitude by the Moon.

Sept. 1, P. M. Moon's Distance observed from Aldebaran.

| Time by the Watch. | Computed Alt. of Aldebaran. | Alt. of the Moon's lower Limb. | Distance of the Moon from Aldebaran. | True Diff. of the Centers. | Apparent Time at Greenwich. | Apparent Time at the Ship. | Diff. of Meridians. | Longitude of the Ship. |
|--------------------|-----------------------------|--------------------------------|--------------------------------------|----------------------------|-----------------------------|----------------------------|---------------------|------------------------|
| h. m. s.           | ° ' "                       | ° ' "                          | ° ' "                                | ° ' "                      | h. m. s.                    | h. m. s.                   | ' "                 | ° ' "                  |
| 11 45 15           | 17 49 0                     | 17 3 0                         | 76 57 nearest limb                   | 77 0 59                    | 11 56 7                     | 12 22 44                   | 26 37               | 6 39 15 E              |
| 12 7 43            | 20 45 0                     | 17 10 0                        | 77 18 farth. limb                    | 76 48 53                   | 12 19 29                    | 12 45 12                   | 25 43               | 6 25 30                |
| 12 22 44           | 22 8 0                      | 17 6 0                         | 76 44 nearest limb                   | 76 44 15                   | 12 27 33                    | 13 0 13                    | 32 40               | 8 10 0                 |

Sept. 3, P. M. Moon's Distance observed from Aldebaran.

| Time by the Watch. | Computed Alt. of Aldebaran. | Alt. of the Moon's lower Limb. | Dist. of Moon's W. Limb from Aldebaran. | True Diff. of Moon's Center from Aldebar. | Apparent Time at Greenwich. | Apparent Time at the Ship. | Diff. of Meridians. | Longitude of the Ship. |
|--------------------|-----------------------------|--------------------------------|---|---|-----------------------------|----------------------------|---------------------|------------------------|
| h. m. s.           | ° ' "                       | ° ' "                          | ° ' "                                   | ° ' "                                     | h. m. s.                    | h. m. s.                   | ' "                 | ° ' "                  |
| 11 30 35           | 17 47 0                     | 24 47 0                        | 39 39 0                                 | 39 57 5                                   | 11 30 43                    | 11 55 47                   | 25 4                | 6 16 0 E               |

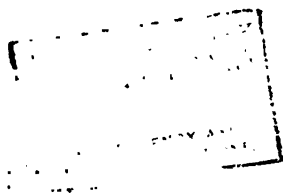
Observations



| Time by<br>the<br>Watch. | Alt. of<br>Jupiter | Alt. of the<br>Moon's<br>lower<br>Limb. | Distance of<br>Jupiter and<br>Moon's<br>other Limb. |
|--------------------------|--------------------|---|---|
| h / "                    | o /                | o / "                                   | o /   |
| 8 51 33                  | 10 25              | 9 0 0                                   | 32 55   |
| 9 3 27                   | 10 59              | 9 36 0                                  | 32 47   |
| 9 32 45                  | 13 19              | 10 55 0                                 | 32 29   |
| 9 51 54                  | 14 40              | 11 36 0                                 | 32 22   |
| 10 38 25                 | 17 45              | 12 49 0                                 | 31 58   |
| 11 43 18                 | 20 52              | 13 6 0                                  | 31 28   |
| 1 35 37                  | 22 45              | 9 55 0                                  | 30 33   |

| Time by<br>the<br>Watch. | Alt. of<br>Jupiter | Alt. of the<br>Moon's<br>lower<br>Limb. | Distance of<br>Jupiter and<br>Moon's<br>other Limb. |
|--------------------------|--------------------|---|---|
| h / "                    | o /                | o / "                                   | o /   |
| 11 59 20                 | 21 55              | 7 8 0                                   | 18 8  |













100-2-11-5

